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NUCLEAR INDIA

VOL. 15, No. 1 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY SEPTEMBER 1976

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*A Novel Prospecting Technique*

# Solid State Track Detectors Help Search for Uranium

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A RECENT IAEA projection puts the world demand for uranium during the remainder of the century at around 4 million tonnes. This could be greater if the trend towards the use of electricity is accelerated and the current global crisis and concern over other sources of energy raw materials continue to be felt. The increase in the demand for uranium is unprecedented in the history of mineral exploration and development, and has clearly brought out the need for embarking on accelerated programmes of exploration for nuclear raw materials, particularly uranium. A thorough search for fissile and fertile materials (uranium and thorium respectively) in the country is essential to get a proper assessment of the extent of their availability. And the success of such a search, leading to new discoveries, will depend to some extent on developing and applying new prospecting techniques capable of detecting deposits hidden under over-burden, and identifying the most tenous surface indications.

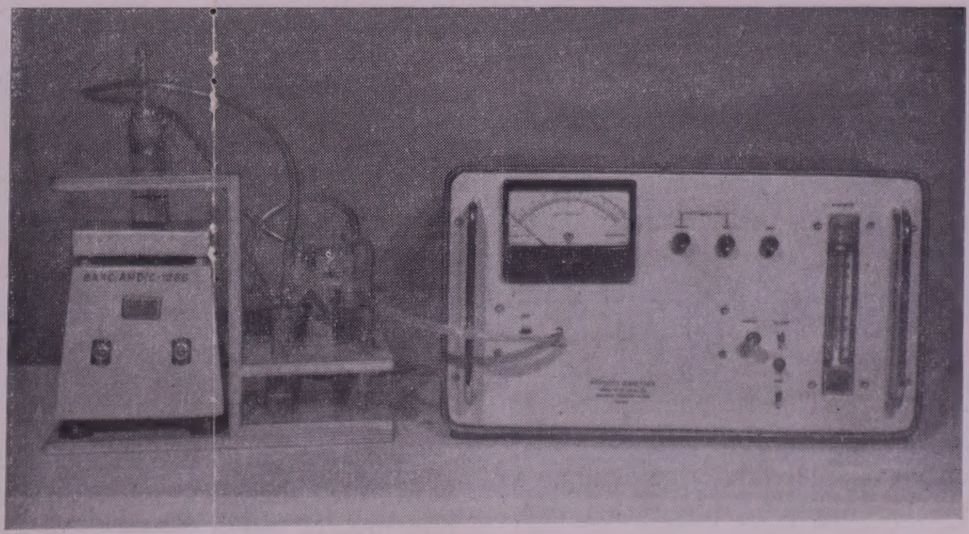
The process of discovering uranium deposits involves a number of stages of systematic operations. It is sufficient to say here that the process involves detailed ground survey of geologically favourable regions after preliminary survey. For an exploration programme to be successful, a judicious combination of methods should be employed; single techniques are rarely wholly effective on their own.

## *Radioactivity of Uranium and Thorium*

Uranium and thorium are radioactive elements and this property of

(*Continued on page 3*)

# A Mercury Analyser from Trombay



MERCURY is one of the most toxic elements among the inorganic pollutants. The age old expression "mad as a hatter" could well have been coined because the mercury compounds used in the hat making industry at one time caused brain damage to the workers.

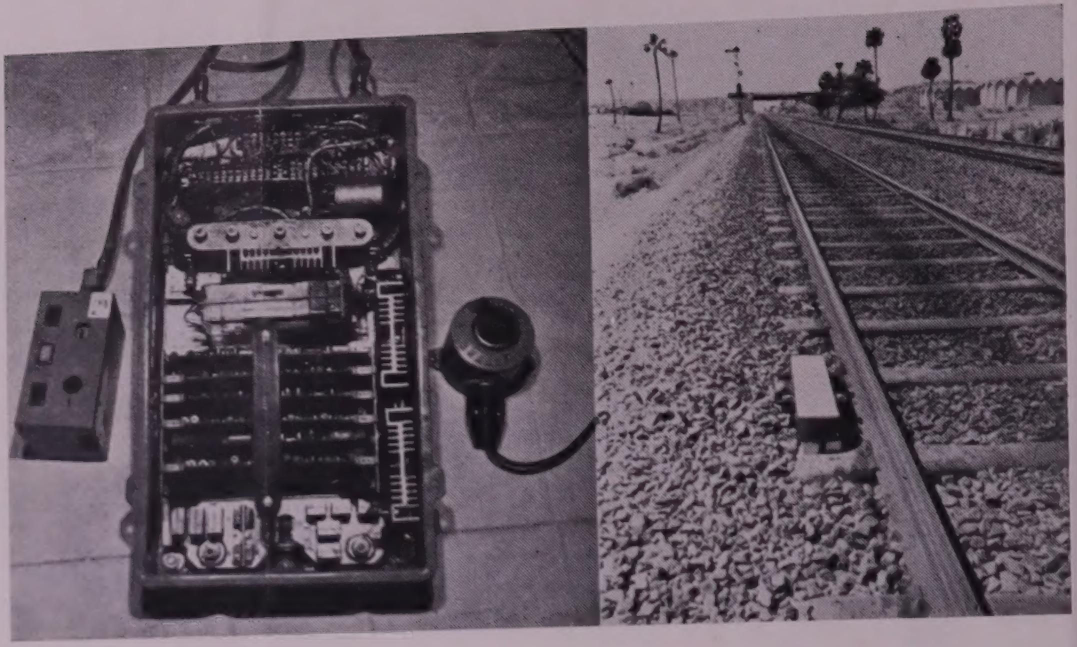
Some years back several people died in the Minamata Bay area of Japan after eating fish contaminated with alkyl mercury. Many more have died in Iraq, Ghana, Guatemala and Pakistan after eating seeds forbidden for human consumption. These seeds had been preserved with alkyl mercury.

The increasing use of mercury and its compounds in industry and agriculture is a major cause of pollution of the environment; consequently high levels of mercury are being found in fish, cereals, fruits, vegetables etc. Much of the mercury found in food products is alkyl mercury

(*Continued on page 2*)

# Rail Travel Will Be Safer With ECIL Device

THE Electronics Corporation of India Ltd. (ECIL), an industrial enterprise under the Department of Atomic Energy, has developed an Automatic Warning System (AWS) which will enhance the safety of rail travel. The all solid state electronics device senses the signal aspect much before the train arrives near the signal post, and forewarns the driver by flashing audiovisual signals inside the driver's cabin. Also, in areas where there are specified speed limits, an audiovisual signal is flashed whenever the limit is crossed. The train is also automatically brought to a halt if the driver fails to reduce his speed.


**Left : the engine equipment comprising indication and alarm panel, evaluator and brake reset switch. Right : the track device.**

The system consists of a track mounted device and the engine equipment. The former, placed at a suitable distance from the signal post picks up the signal relayed from the signal post, and sends it to the engine device through a set of three permanently energized tuned inductors mounted under the engine chassis.

A 'clear' signal is indicated by the ringing of a bell; a normally lit blue lamp is also extinguished for a few seconds. A 'danger' signal is indicated by the glowing of a white lamp and the sounding of a hooter. Once the brake is automatically applied, the engine can be re-started only when the driver gets down from the train and presses a brake-reset switch. ●

## Know-how Available to Industry

*(Continued from page 1)*

Much of the mercury found

which is known to be one of the most toxic forms of this element. Hence the need to effectively monitor the release of mercury into the environment and to ensure that the eco-system is not contaminated.

The Analytical Chemistry Division at BARC has fabricated an equipment for the determination of mercury at 'nanogram' ($10^{-9}$ gm) levels in different types of materials. The Mercury Analyser is basically a 'cold vapour' Atomic Absorption Spectrophotometer. It consists of a low pressure mercury vapour discharge lamp, a specific filter, an absorption cell, an IP-28 photomultiplier detector and necessary electronim circuitry.

The mercury present in any chemical form is converted into ionic divalent form which is again converted to the metallic form by reduction with stannous chloride in a reaction vessel. A 'fish tank aerator' draws the mercury vapour from the reaction vessel into the absorption cell, which is illuminated by the mercury discharge lamp. The mercury vapour in the cell absorbs the radiation at 253.7 nm and causes a change in the transmittance, which is a measure of the mercury content. The sensitivity is 3 ng (absolute) of mercury for 1 per cent absorption.

The Mercury Analyser can be used for the determination of mercury in water, brine, urine, gases like air, $N_2$, $O_2$, $H_2$, marine products, agricultural products, metals, alloys, river sediments, soils, minerals, paints, cosmetics etc. In fact, the present equipment has been in use for the past one year for the analysis of these very types of samples.

The first unit of the Analyser is to be supplied to the Marine Products Export Development Authority, Cochin to help in the quality control of nearly Rs. 100 crores worth of consignments of marine products for export.

The estimated cost of the Analyser is Rs. 10,000 of which the foreign exchange component is just Rs. 600. Its performance in terms of sensitivity and stability is comparable to that obtained with an Atomic Absorption Spectrophotometer costing Rs. 60,000. Its performance is also superior to that of an imported Mercury Analyser which costs around Rs. 20,000.

**The know-how for manufacture of this unit is available to industry from BARC.**

# BARC TEFUREX—A Technique For Uranium Exploration

(*Continued from page 1*)

theirs assists in their location and evaluation by methods based on measurement of radioactivity. Deposits of uranium and thorium are always associated with alpha, beta and gamma activity. Beta and gamma radiations may be detected by hand-carried G-M and NaI (Tl) scintillation counters. However, the beta-gamma radiations from uranium and thorium deposits which lie buried deep in the soil may sometimes be masked, thereby preventing their detection. For identification of sub-surface uranium mineralisation zones, measurement of alpha activity proves effective. It is therefore useful to know how it can be done.

### Radon Measurement

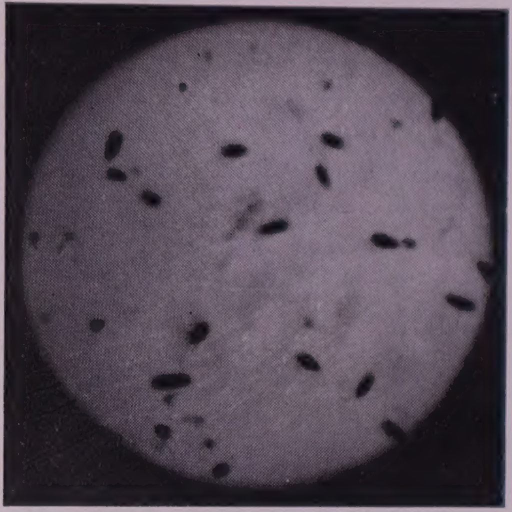
Among the radioactive decay products of uranium is a noble gas—radon ($^{222}$Rn)—which decays with a half-life of 3.8 days by emitting energetic alpha particles. Because it is a noble gas (chemically less reactive), it can diffuse or be transported some distance through fissures in the rock structure and through unconsolidated material, and find its way into the soil and surrounding atmosphere. Therefore, among the radiometric techniques, radon measurements seem to be the most promising for detecting the uranium deposits that are buried too deep to be located by surface or airborne beta-gamma detection technique. And, unfortunately, many of the world's yet undiscovered geological targets for uranium seem to be buried deep. In actual practice, a 'radon map' of the region to be explored is made by measuring the concentration of radon in the soil gas at different places by means of suitable instruments. The 'radon map' indicates regions of high concentrations of radon (called radon anomalies) which helps in outlining the ore-body. Such delineation of the mineralised zones leads to substantial savings in exploratory drilling costs by limiting/eliminating unproductive bore hole drilling. It should be noted, however, that occasionally the interpretation of the 'radon map' becomes complicated because of disequilibrium between uranium and radium-226 (which is the source of radon-222), variation in emanation, porosity of the soil, ground water movement etc.

One of the conventional methods of sampling soil gas is to measure the alpha radiation due to radon and their decay product in a small sample of soil gas pumped from the surface soil. The detector is usually a chamber coated with alpha sensitive phospor (ZnS) connected to a photomultiplier. This method has been, and is still being employed successfully in the exploration programmes of the Atomic Minerals Division of the Department of Atomic Energy.

## *The Track Detector Technique: 'BARC-TEFUREX'*

In view of the importance of radon mapping in uranium exploration, and problems associated with the conventional techniques, a search has been on for a detection system which is operationally simple, amenable to extensive field application and also free from the drawbacks of the conventional systems. Basic as well as applied research and development work carried out at BARC on the trajectory of heavy ionising radiations in insulating plastics has enabled the scientists to design an extremely simple and novel track detector system to accomplish this objective, and to develop a process called BARC-TEFUREX (Technique for Uranium Exploration).

Readers have been introduced to the basic principles, advantages, and the many interesting applications of solid state track detectors in an earlier article in *Nuclear India* (*Vol. 9, No.* 11, July 1971). BARC-TEFUREX is yet another important application and constitutes an attempt at taking scientific knowledge developed in the laboratory to the field for potential economic good. The technique is based on the principle that alpha sensitive plastic strips register tracks of alpha particles from the decay of radon-222. The alpha tracks recorded permanently on the detector strips are revealed by simple chemical treatment and seen under an optical microscope. A photograph of the tracks of charged particles as seen under microscope is shown below.



**Photograph of tracks of charged particles in plastics**

In practice, the detector is exposed to the soil gas as shown in the figure on page 6. In the first arrangement, the detector is suspended vertically at the axial position inside a hole (about 0.6 metres deep) which can be made by a simple hand-driven auger or crowbar. The detector is mounted on a thick paper or PVC support held inside the hole by a string from the centre of the cardboard covering the mouth of the hole. In the second arrangement, the detector is fixed at the inside bottom of a small tumbler, and this system, designated as DTS, is buried in an inverted position at a depth of about 0.6 m inside the soil. The figure also

(*Continued on page 6*)

# Answers in Parliament

### Uranium Occurrences

The Atomic Minerals Division of the Department of Atomic Energy has located promising occurrences of uranium near Dumhat and its environs in Sarguja District, Madhya Pradesh. Radioactivity due to uranium has been detected along a prominent shear zone. Detailed investigations are being carried out in the area.

*(Lok Sabha, August 11, 1976)*

* * *

Promising occurrences of uranium have been located near some villages in Chikmagalur District, Karnataka by the Atomic Minerals Division of the Department of Atomic Energy.

The occurrences are being investigated in detail. Exploratory bore hole drilling is in progress near Kalasapura and Devagondanhalli villages to assess the potentialities of the area.

*(Rajya Sabha, August 12, 1976)*

### Fuel for Tarapur

The licence for export of enriched uranium from the USA for the Tarapur Atomic Power Station (TAPS) had been held up as a result of petitions filed with the Nuclear Regulatory Commission of that country seeking to block the export. The Government of India are in constant touch with the US State Department which, as per normal diplomatic practice, is presenting India's views before the NRC. As a result of these efforts a part consignment of enriched uranium has been received on July 23, 1976. No hindrance in the functioning of TAPS is apprehended unless release of the remaining quantity is delayed beyond the end of 1976.

*(Rajya Sabha, August 12, 1976)*

NUCLEAR INDIA
is a monthly publication of the Department of Atomic Energy, published around the 20th of each month. To ensure prompt attention, all communication should be addressed to the Editor, NUCLEAR INDIA, Department of Atomic Energy, Chhatrapati Shivaji Maharaj Marg, Bombay 400 039. While intimating change of address, the code and number given on the wrapper should be mentioned. Bombay recipients may contact 25 04 77 for prompt action.

### Self-Reliant Nuclear Power Programme

India is not depending to any substantial extent on import of equipment for the execution of nuclear power projects. There will, however, be some delay in the completion of the second unit of the Rajasthan Atomic Power Station, and the Madras Atomic Power Station due to embargo on supply of certain materials and equipment imposed by Canada and the time taken in locating alternative sources.

All items of equipment of a sensitive nature are either already manufactured or are in the process of being manufactured within the country.

*(Rajya Sabha, August 12, 1976)*

### Nuclear Co-operation

India has entered into bilateral agreements for co-operation in the peaceful uses of atomic energy with Afghanistan, Argentina, Bangladesh, Belgium, Canada, Czechoslovakia, Denmark, Arab Republic of Egypt, France, Federal Republic of Germany, German Democratic Republic, Hungary, Iraq, Romania, Spain, United States of America and the Union of Soviet Socialist Republics.

Iran, Indonesia and Peru have sought India's co-operation in the development of nuclear energy for peaceful purposes.

*(Rajya Sabha, August 19, 1976)*

### Industrial Complex

Indian Rare Earths Ltd., a public sector undertaking under the administrative control of the Department of Atomic Energy, is setting up an integrated industrial complex for the commercial exploitation of rare earth mineral deposits in Orissa.

*(Lok Sabha, August 25, 1976)*

# At Kalpakkar

THE two-unit 420 MWe nuclear power station at Kalpakkam, near Madras is fast taking shape.

This CANDU type natural uranium fuelled, heavy water moderated station is being built by the Power Projects Engineering Division of the Department of Atomic Energy.

Important reactor components such as the reactor vessel (Calandria), fuelling machines etc. as well as the instrumentation and control equipment, and the fuel and heavy water are coming from Indian sources.

### Special Features

The station has a special feature which deserves mention. The prestressed concrete building design adopted for it is one of the first double shell nuclear containments in the world for such a reactor system. The 0.65 metre thick perimeter wall of prestressed concrete forms the inner shell, while the 0.71 metre thick reinforced rubble masonry wall forms the outer shell. This design provides a highly leak-tight containment structure even in the absence of an expensive steel containment.

The two reactors will be fuelled with a total quantity of 112 tonnes of natural uranium dioxide fuel. Subsequently, they will together need only about 200 kgs of fuel per day. For a coal-fed station of this size, 5,000 tonnes of coal would be required every day.

The two reactor units require approximately 3,180 million litres of water per day for condenser cooling purposes. The water for this purpose is drawn from the sea through a submarine tunnel about 65 m below grade level. The tunnel is 468 m long and 3.8 m in diameter. It is horse-shoe shaped and connects the

*Important reactor components, including the reactor vessel, the fuelling machines, etc. are being built by Indian engineering firms. The instrumentation and control equipment are being supplied by the Electronics Corporation of India Ltd. The fuel bundles will be fabricated at the Nuclear Fuel Complex at Hyderabad. The natural uranium to be used for fuel bundles is extracted at Jaduguda in Bihar and processed there by another public sector undertaking, the Uranium Corporation of India Ltd. Zirconium alloy components, namely the calandria tubes, pressure tubes and fuel sheathing will also come from the Nuclear Fuel Complex at Hyderabad. And heavy water required for the reactors will come from the heavy water plants now under construction.*

# ndian Nuclear Technology Shows its Paces

**A view of the Madras Atomic Power Station. The reactor buildings are seen in the centre.**

intake structure in the sea to the pump house on the shore. Fish and other large size particulate matter coming in the sea water are arrested by the travelling water screens located in the pump house. The sea water, after passing through the condenser, is discharged back to the sea on shore through the outfall structure.

Another novel feature of this station concerns the adoption of a closed indoor switchyard for housing all the circuit breakers, isolators and other switchyard equipment. After studying the experience of other coastal stations in India and abroad, it was concluded that it would be technically appropriate to employ an enclosed switchyard at Kalpakkam where salinity in the atmosphere is very high. ●

# Search for Uranium

(Continued from page 3)

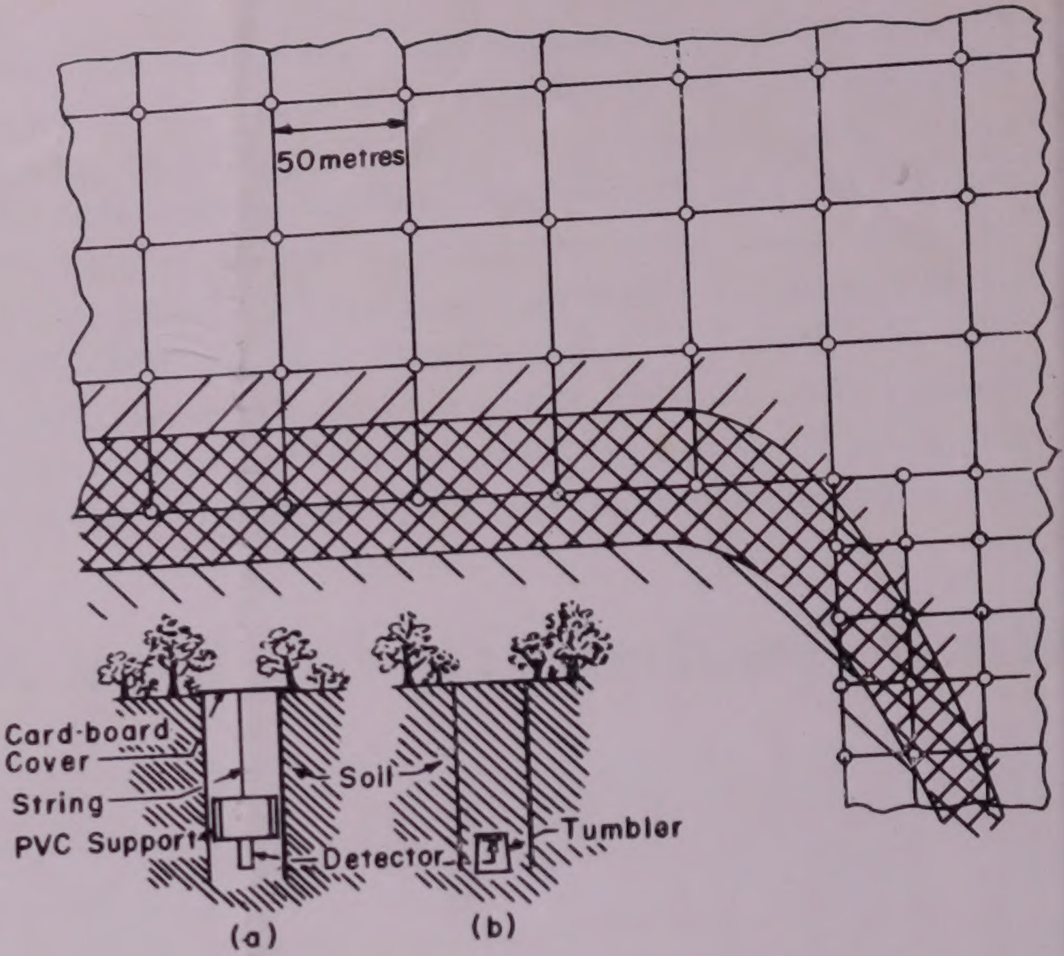
shows a number of such locations (small open circles) in a grid pattern over a prospective area. Once implanted in this manner, the detectors are left unattended and retrieved after a few weeks. The detectors continuously monitor the radon concentration in the soil and accumulate the data. The integral nature of this system is of great advantage in that it permits sampling of the soil gas for extended periods of time (usually a few weeks) thereby eliminating possible errors arising from variations in the radon concentrations due to variations in barometric pressure, temperature, wind conditions etc. This ensures the reliability of the data collected.

### No Moving Parts

The DTS system is very light and compact and requires only the simplest of field equipment for deployment in the field. There are no moving parts or electronic components. Therefore, there are no mechanical or electrical breakdowns to worry about. The number of tracks registered per unit area of the detector (track density) is directly proportional to the radon content of the soil gas; the relative values of track densities at different points give a measure of the radon content at those points and hence the probability of occurrence of uranium in the vicinity. A statistical analysis of the data obtained on a large number of locations in an area enables one to get an idea of the possible mineralisation zone, thus limiting or eliminating the number of bore holes to be drilled in the subsequent stages of the exploratory programme and resulting in an enormous saving in the drilling costs.

After the development of the technique in the laboratory, it was field-tested in areas of known uranium occurrences in a joint programme undertaken by the Atomic Minerals

(Continued on page 8)



**A typical grid layout where uranium mineralized zone (shown by the shaded area) was identified and compared with conventional technique. (a) shows detector exposed in an auger hole. (b) shows detector-tumbler system (DTS) buried in the soil. Below, a typical terrain where detectors have been implanted.**

*Seminar at TIFR*

# Access to Bibliographic Data Bases

A NUMBER of computer-readable bibliographic data bases with international coverage and scope are presently being brought out by foreign commercial agencies, government departments, professional bodies, and scientific and technical institutions. Some of the popular data bases in the field of science and technology are CA CONDENSATES for chemistry and chemical technology, BA PREVIEWS for biological sciences, COMPENDEX for engineering, INSPEC for physics, electrotechnology, computer and control, MEDLARS for medical sciences, INIS for nuclear sciences, NASA for aerospace sciences, AGRIS for agricultural sciences and technology and SCI (Science Citation Index). The advent of computers in the information field has made possible not only the creation of such data bases but also efficient and fast access to world sources of scientific and technical information for purpose of current awareness literature service as well as retrospective literature service.

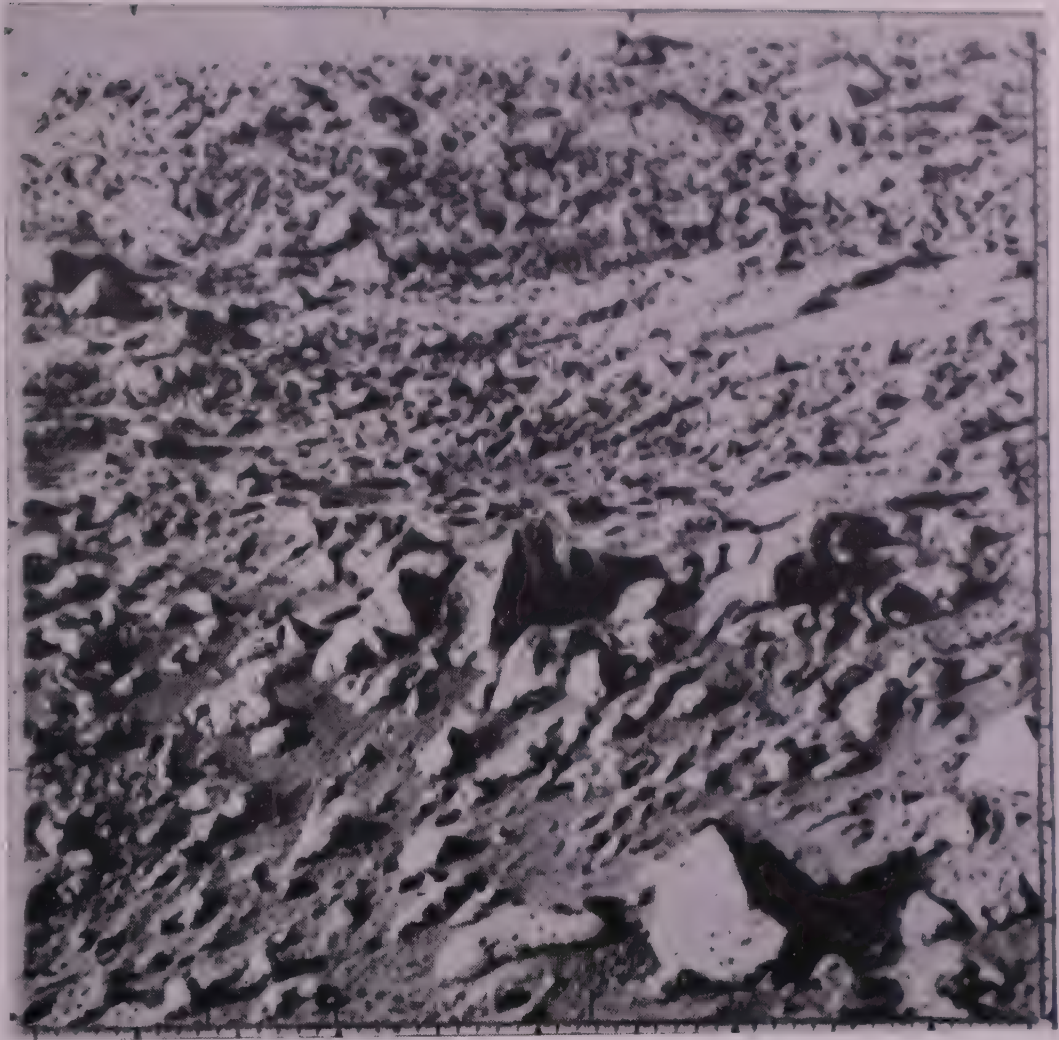
A beginning has been made recently in India to develop computer-based SDI service. An experimental project using CAN/SDI software and with CA CONDENSATES data base is being carried out at IIT, Madras. This project is being supported by UNESCO/UNISIST, Paris. The successful outcome of the project will enable the organisation of systematically computer-based SDI service, using several of the available machine-readable bibliographic data bases for the benefit of a large number of users.

Development of telecommunication facilities has made long-distance on-line information retrieval possible. The network concept is also thereby gaining currency throughout the world. In order to demonstrate the possibility of introducing in the developing countries on-line interactive information retrieval systems using telecommunication facilities, UNESCO/UNISIST is sponsoring in India a project, *viz* "ESRIN/RECON On-line Demonstration Project-Linking to World Sources of Information." The ESRIN Centre in Frascati near Rome, which has about a dozen data bases and access to about 7.5 million references in science and technology drawn from the data bases would be made accessible in the demonstration project.

The demonstration is being held in the Tata Institute of Fundamental Research, Bombay, during 20-25 September 1976. It is being organised by the Department of Science & Technology, in collaboration with the P & T Department, the Overseas Communication Service, the TIFR, BARC and INSDOC. During the demonstration, the data bases in ESRIN, Frascati, can be searched from a terminal at TIFR. The retrieved references can be seen on a screen and can be had as a print-out.

A seminar on "Access of Bibliographic Data Bases" is being organised at TIFR on September 18, 1976 by BARC, Documentation Research Training Centre, Bangalore and the Indian National Scientific Documentation Centre, New Delhi.

## *Martian Landscape*



**The Viking I lander took this high-resolution picture of Mars' terrain on July 22—the third day of its landing. Distance from the camera to the near field (bottom) is about four metres and to the horizon about three kilometres. The large block on the horizon is about four metres wide. Distance across the horizon is about 34 metres. The photo shows numerous angular blocks ranging in size from a few centimetres to several metres. The surface between the blocks is composed of fine-grained material.**

# Extremely Simple, Reliable Method

*(Continued from page 6)*

Division, and the Radiochemistry Division of BARC. Since then, the technique has been deployed in several exploration programmes in various places in India and has yielded positive results. The reliability and usefulness of the technique has been established beyond doubt. As it is very simple and inexpensive, it can be implemented easily. Only unskilled labourers and simple instruments are required for field work.

### Valuable Tool

Apart from these localised field studies, the possibility of using the track detector system for detecting ground radon anomalies over large areas has been considered. One approach to this problem is to air-drop detector strips attached to small envelopes over the area under investigation so that they spread over a large area and settle on the ground.

As a preliminary trial, a small number of the detector envelope system was air-dropped in certain selected places during a recent aerial survey. In this programme, the help of the local administration and local people was sought for retrieval of the detector strips thereby involving the people at large in the application of science and technology. The experiment has brought to surface some practical problems regarding the recovery of the detectors. Nevertheless, it is heartening to note that the experiment—the first of its kind to be conducted—did yield useful and interesting information.

In conclusion, the unparallelled simplicity and reliability of the track detector technique makes it a valuable tool in the search for uranium. It is a case of basic research yielding demonstrable practical results. We believe this technique will play a vital role in the future/current exploration programmes. ●

## *Giant Atom Prober*

**A 137 tonne magnet, one of the largest ever built, is hoisted into place as part of a high resolution spectrometer at the Los Alamos Scientific Laboratory in New Mexico, U.S.A. The extremely sensitive instrument is expected to give U.S. investigators their best look at minute particles, including the nuclei of atoms themselves.**

Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India
Chhatrapati Shivaji Maharaj Marg, Bombay 400 0[illegible] and printed by him at G. Claridge & Co. Ltd., Bombay 400 001

**Registered No. R. N. 9002/62**

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# NUCLEAR INDIA

VOL. 15, No. 2 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY OCTOBER 1976

## BARC's RIA Kit Enables Early Detection of Risk Pregnancies

THE Bhabha Atomic Research Centre and the Institute of Research in Reproduction (ICMR), Bombay have jointly developed a radioimmunoassay kit for human placental lactogen.

Human placental lactogen (HPL) is a hormone present in the blood of pregnant women. If the pregnancy is normal and if no complications arise, the concentration of this hormone rises rapidly in the early weeks of pregnancy. In case of complications which may lead to foetal distress or neonatal asphyxia or abortion at a later stage, the HPL level in the blood/serum will be significantly lower than the normal. **A large majority of such pregnancies may not manifest any other symptoms of abnormality and thus radioimmunoassay of HPL is the only method now available for the detection of such complication at an early stage of pregnancy.** Closer obstetrical management would be required for all such patients. In cases where there is a positive indication of abortion at a later stage, early medical termination of pregnancy may be warranted. HPL determinations are also of considerable diagnostic value in pregnancies complicated by diabetes or erythroblastosis.

In radioimmunoassay (RIA) of HPL, a small aliquot of the patient's blood is withdrawn and the serum separated out. To the separated serum, a known quantity of antibody of HPL (obtained from immunised rabbits) is added, followed by a known quantity of labelled HPL (labelled with Iodine-125) of high purity and specific activity. The antibody specifically binds HPL (both labelled and unlabelled), and the radioactivity bound to the antibody gives an accurate measure of the concentration level of HPL present in the patient's serum. **It may be emphasised that no radioactivity is administered to the patient in this assay; hence no radiation dose is delivered to the patient.** This procedure can therefore be readily adopted for serial investigations throughout the term of pregnancy.

Radioimmunoassay of HPL is a very valuable placental function test and could also serve as a screening procedure to detect risk pregnancies, thus enabling better medical management of such cases.

### Kits for Other Hormones

The Radiopharmaceutical Section of BARC has made significant progress in the development of RIA kits for other important hormones including human thyroid stimulating hormone, triiodothyronine, thyroxine, follicle stimulating hormone and human chorionic gonadotropin. The availability of these kits will enable the hospitals to introduce a wide spectrum of extremely valuable in-vitro diagnostic tests which will benefit a large cross-section of the population of this country. ●

### Demonstration at TIFR

## *Instant Access to Global Data Bases*

A RECON on-line demonstration was organised for the first time in India (and in Asia) by the Department of Science and Technology at the Tata Institute of Fundamental Research, Bombay during September 20-25.

This system was originally developed by the Lockheed Corporation of the USA for that country's National Aeronautics and Space Agency (NASA).

This pilot project was arranged in collaboration with a number of other organisations, Indian and international, namely, the Ministry of Communications, INSDOC of the Council of Scientific and Industrial Research, the Bhabha Atomic Research Centre, the Tata Institute of Fundamental Research, UNESCO, and the European Space Agency.

RECON is a remote access, on-line interactive retrieval system which permits the user to retrieve instantaneously information held in ESRIN, Frascati in Italy. Terminals are now located in France, the Netherlands, Britain, the Federal Republic of Germany, Spain, Sweden and Denmark. A terminal was recently set up at Rabat, Morocco. This network covers 10,000 km and has 26 terminal nodes all over Europe.

The ESRIN Centre has at present more than 10 data bases and provides access to over 7.5 million references drawn from them. The monthly addition comes to 100,000 references.

The object of the project was primarily to demonstrate the application of modern telecommunication techno-

(*Continued on page 8*)

# Policies, P
# Of Nucle

THE Annual Report of the Agency has identified a number of important areas of the Agency's work during the past year, such as assistance to Member States in the introduction and development of nuclear power, nuclear safety, environmental protection, information exchange and application of nuclear techniques in agriculture. We fully support these activities which are of interest and concern to all Member States of the Agency.

We note the progress of work relating to the study for the regional fuel cycle centres. We have made available the services of a senior expert as the project leader for this study. Whilst we shall continue to cooperate fully with the Agency in this study, I am somewhat apprehensive of the complex legal and techno-political considerations which might influence the setting up of such regional centres.

With regard to the work of preparation of safety codes and guides, my delegation would like to mention that we in India have just gone through such an exercise to meet the specific needs of our own programme. We have made available this experience to the Agency. I trust that during the preparation of these codes and guides the Agency would ensure that these are exclusively related to safety, and no other considerations are allowed to dilute their effectiveness. My government will continue to make available experts to the Agency as and when required. India's experience thereby becomes available for use in other developing countries.

The Ad Hoc Advisory Group on Nuclear Explosions for Peaceful Purposes has made some progress in identifying major practical applications, both present and potential, of PNEs and in studying their economic, health and safety and legal aspects. The participation of a large number of Member States of the Agency in the work of the Ad Hoc Group is in itself an indication of the growing interest among the Member States in allaspects of the application of PNEs. The draft report of the Ad Hoc Group, which is based on technical expertise of a number of countries, clearly brings out the potential benefits of this technology. It is however somewhat disturbing that in some quarters, these benefits are often perhaps conveniently ignored for extraneous considerations.

When finalising the examination connected with the legal aspects of PNEs, which would presumably lead to the development of an international PNE regime, I would like the Agency to keep in mind that India would be willing to make available its experience and knowhow under appropriate international procedures and agreements.

The budget of the Agency for 1977 as recommended by the Board of Governors once again represents a considerable increase in expenditure over the current year. We naturally welcome a sustained and realistic growth in the programmes and operational activities of the Agency from year to year. But there seems to be considerable scope for exercise of economy and the Agency should be well advised of expenditure in spheres unrelated to the actual operational needs of the organisation. Let it not be forgotten that the developing countries are particularly adversely affected by the sharp increase in the regular budget.

### Voluntary Contributions

The Board of Governors have recommended a target of U.S. dollars 6 million cash for voluntary contributions to the General Fund for technical assistance in 1977. This represents only a modest increase over the target for this year but we take it, nevertheless, as an indication of the increasing importance attached to the technical assistance activities of the Agency. My Government has always fully supported the technical assistance activities of the Agency and we are glad to announce a contribution equivalent to U.S. dollars 74,400 in our national currency to the General Fund for 1977. We will also continue to provide fellowships and services of experts to other developing countries through the Agency's technical assistance programme, in addition to providing facilities for scientific visits. It is our hope that the target for voluntary contributions would be fully realised and that the Agency would also be able to enhance its delivery capacity, eliminating as far as possible, delays or bottlenecks in implementation of its technical assistance programme.

**My Government is both a donor and a recipient of technical assistance. We naturally view with concern the tendency of certain advanced states to apply restrictive policies in regard to provisions of technical assistance in the form of fellowships, scientific visits etc. We trust that well established principles relating to the provision of technical assistance shall be preserved and there would be no discrimination in any form in the provision of technical assistance to all countries.**

With regard to safeguards we have consistently held the view that the Agency's safeguards function should be exercised strictly in accordance with the provisions of its Statute. The Director General has constituted a Standing Advisory Group on Safeguards Implementation to advise him on technical aspects of the Agency safeguards. We are confident that the deliberations of this group will concentrate on the important task of assessing the technical effectiveness of safeguards implementation within the scope of the present system, leaving aside other issues.

Nuclear power has now become an accepted alternative to conventional power in many countries in terms of technological developments and economic evaluation, particularly in the context of steadily increasing oil prices and growing shortage of other fossil fuels. It may be safe to assume that within the next 25 years, a substantial part of the world electrical power requirements will be met by nuclear

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*Excerpts from the statement of Dr. H. N. Sethna, Chairman, Atomic Energy Commission and leader of the Indian delegation to the 20th session of the General Conference of the International Atomic Energy Agency on 22nd September, 1976 at Rio de Janeiro, Brazil.

*l General Conference*

# dures Inhibiting Growth chnology Must Be Avoided

reactors. Recognising the need for diversification of energy sources and the immediate compulsions to meet energy demands, many developing countries have embarked on nuclear power plant construction programmes. Of late, however, there have been certain trends which may tend to inhibit the projected growth of nuclear power.

In view of the significant role played by the Agency in the past in the field of nuclear power, there will, no doubt, be new dimensions to its responsibilities in the fast changing energy picture in the near future. In considering the future development, we can clearly visualise "opportunity peaks" for extended use of nuclear power. At the same time we have to devote serious consideration to the possible consequences of increased use of nuclear energy, assured supplies of fuel, siting and safety problems, as well as management of radioactive wastes and other problems for which solutions will have to be found on regional or international basis. This represents a delicate equilibrium between the demands of safety for nuclear installations and allied facilities, and the need for speed in using nuclear technologies for transforming the pace and direction of the effort to meet the revolution of rising expectations in the developing countries and in attaining the goals of economic growth and social welfare.

**In view of the magnitude and importance of these objectives, we should scrupulously avoid any new policies or unilateral procedures which would impose limits on the growth of nuclear technology and the great promise it holds for the future. Let us not miss the "opportunity peaks" and unwittingly usher in the paradox of shrinking nuclear programmes by introducing constraints which obviously fall outside the domain of either technology or economics. Therefore, it is a matter of concern to see moves in recent sessions of the Board of Governors to introduce new concepts into the safeguards system which are bound to result in modifying the rationale and structure of the Agency's safeguards system to a degree unacceptable to the entire memberships of the Agency. While we do respect treaty obligations and other considerations that certain states might have, these should not be used to modify the basic statutory principles underlying the Agency's safeguards system or to impose new restrictions or obligations on the membership of the organisation as a whole. At a time when a number of developing countries are on the threshold of development of nuclear power, introduction of such restrictive policies might well result in seriously hampering the efforts which I am sure, cannot possibly be the objective or intention on the part of any Member State.**

I would like to briefly mention some of the achievements of India's nuclear programme over the past year. Construction of the power stations at Kota, Kalpakkam and Narora is progressing well. The first unit of the Canadian-assisted Rajasthan Station at Kota continues to give us problems which we are overcoming by supply from indigenous sources. The Nangal Heavy Water Plant has completed 14 years of commercial production. The Baroda Heavy Water Plant has just completed its commissioning test and the Kota, Talcher and Tuticorin Plants are in various stages of installation. Our Fuel Fabrication Plant at Hyderabad has gone into full commercial production. This plant produces finished fuel elements as well as a wide range of zirconium and zirconium alloy products from local ores. The production of zircaloy pressure tubes, calandria tubes fuel cladding tubes has been established. We have recently completed the fabrication of over 200 fuel bundles for the Tarapur Station using U.S.-supplied U-235 enrichment. Nearly 2,500 natural uranium fuel bundles have been fabricated for the Rajasthan Station. The construction of the fuel reprocessing plant at Tarapur has been completed and the plant is under commissioning runs. We are confident that the final reprocessing costs, including waste management, will be lower than three quarters of the indicative cost of such services that may be available on a commercial basis.

### Waste Management

As a vital aspect concerning the environment, I would now like to mention briefly an important activity, namely, radioactive waste management and its public acceptance. It has always been our endeavour to ensure widest awareness and appreciation in our country of this problem in all its facets. Unfortunately, press reports appearing in some countries, which I am afraid are not always unmixed with other overtones and implications, present a distorted picture. I refer especially to some reports which lately appeared in the press in certain countries concerning radioactive discharges from one of our installations. I would like to say that they are completely incorrect and without substance. **The radioactive waste management in the Indian nuclear programme has continued to ensure that man and environment are not endangered due to release of radioactivity.**

Early in the planning of our nuclear programmes, it was recognised that safe management of radioactive wastes should be a significant requirement for an integrated approach. More than a decade before the commissioning of the power reactors, special importance was attached to studies relating to impact of radioactivity on the environment. As a matter of policy, we have stipulated that the responsibility for the safe management of radioactive wastes should be placed under an independent unit answerable to the health and safety authorities and not to the facility operator. In furtherance of this, ex-

(*Continued on page 8*)

# Life on M

**Will Mars have at least some primitive**
**processes and evolution of life on earth**
**organisms on the Mars. And the data fr**
**this conclusion. Dr. V. S. VENKATAW**
**search, Bombay discusses the concept o**
**experiments. The illustrations are by c**

THE long cherished dream has come true. For about a century, from the discovery of the so-called 'canals' on Mars by the Italian astronomer Giovanni Schiaperalli, men have wondered whether there could be intelligent life on Mars. Now there are two intelligent machines on the Martian surface trying to detect Martian micro-organisms. The landers of Viking-1 and Viking-2 missions are equipped with miniature biological laboratories capable of detecting life on Mars. Preliminary data from Viking-1 have given encouraging results regarding the possibility of life on the planet. This is yet to be confirmed. Viking-2 which has landed in a region containing five times more water vapour than the Viking-1 site, has also started analysing the Martian soil and the results are expected in a couple of weeks time.

### Intuitive Definition

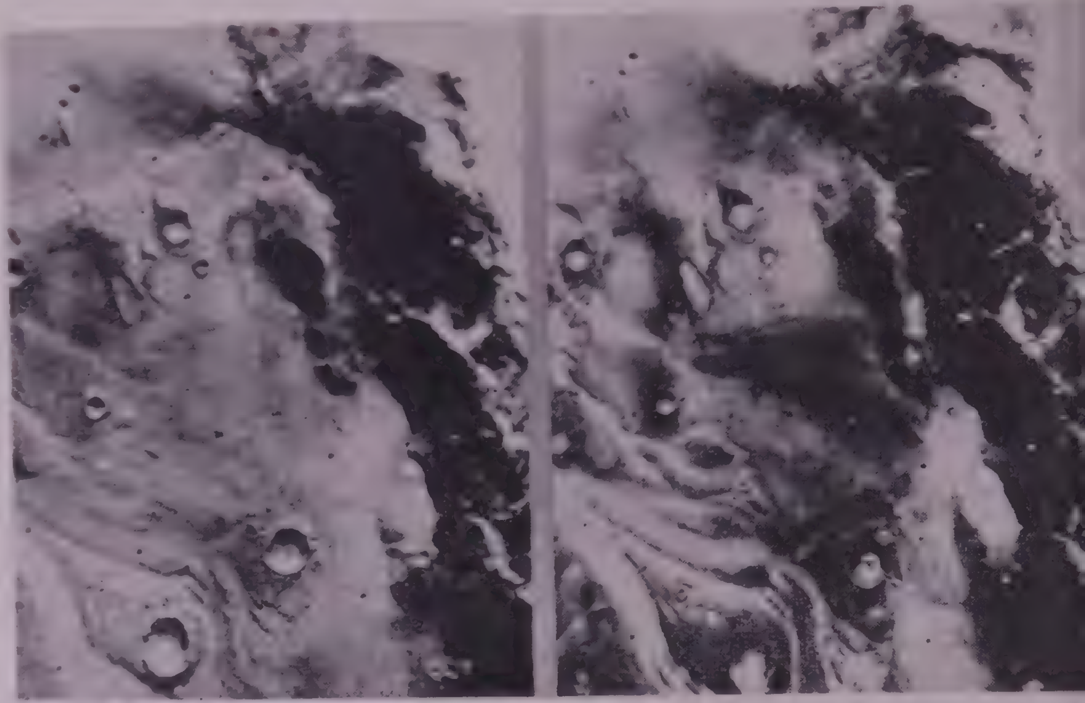
Before going on to the discussion on life on Mars, let us contemplate a little on the question, "What is life"? A little reflection will make obvious the fact that it is difficult to define life precisely. For instance, consider the succinct definition of life given by Nietsche, the German philosopher:

> "*Life is an instinct of growth, for survival, for the accumulation of forces, for powers*".

This rather poetic definition of life would include the roaring ocean or tropical cyclone as having attributes of life. Any other definition of life would also be as incomplete and subjective.

Assuming an intuitive definition of life, we again come across primitive life and advanced forms of life. Then there are the plants and animals and all their different classifications. At the primitive level, the distinctions between plants and animals are not apparent. On the other end of evolution, we have intelligent life among advanced animals culminating in the so-called 'conscience' in man. Conscience again is an unique quality which probably occurs only in an advanced form of life such as man. So, when we talk about life on Mars, we should also specify what form of life we have in mind. Before the landing of Viking missions on Mars, optimists could think of all forms of life, including advanced civilizations capable of constructing long canals. Now, after the Viking missions, we would be satisfied even with the most primitive form of life.

After all, the earth itself had only very primitive form of life some three and a half billion years ago! Any explorer from extraterrestrial civilization during that time would have found just what we expect to find on the Martian soil—some primitive unicellular organisms. Earlier than about three and a half billion years there was probably no life on earth. The earth's atmosphere did not have any oxygen.



WATER ON MARS. Two photographs taken half an hour after each other from Viking I orbiter. The picture at left was taken shortly after dawn and the right 30 mins. later. See the development of fog in low spots marked by arrows in right figure.

The atmosphere of the earth must have resembled the atmosphere of present-day Jupiter, with ammonia, methane and water vapour as the major constituents. It is speculated that some organic compounds which are precursors of life were produced in the earth's primitive atmosphere due to the interaction of solar ultraviolet light. Laboratory experiments conducted by Stanley Miller and others have proved that such reactions are indeed possible.

The experiments have shown that in
laboratory simulation of the conditions
of primitive earth, organic compounds
such as amino acids, which are the
building blocks of proteins of life, were
created. By some yet unknown and
miraculous process the first unicellular
organism evolved out of these organic
compounds. After this, it is only a
question of time for the evolution o
higher forms of life. This evolution ha
been going on for the past billions o
years. Every one of us, in some wa
bears the record of that unique proces
—the generation of life from non-life-
that took place more than thr
billion years ago. There has been a
unbroken chain of evolution over a
these years leading to all the livi
things we see around—from a ti
bacteria to a fully grown man.

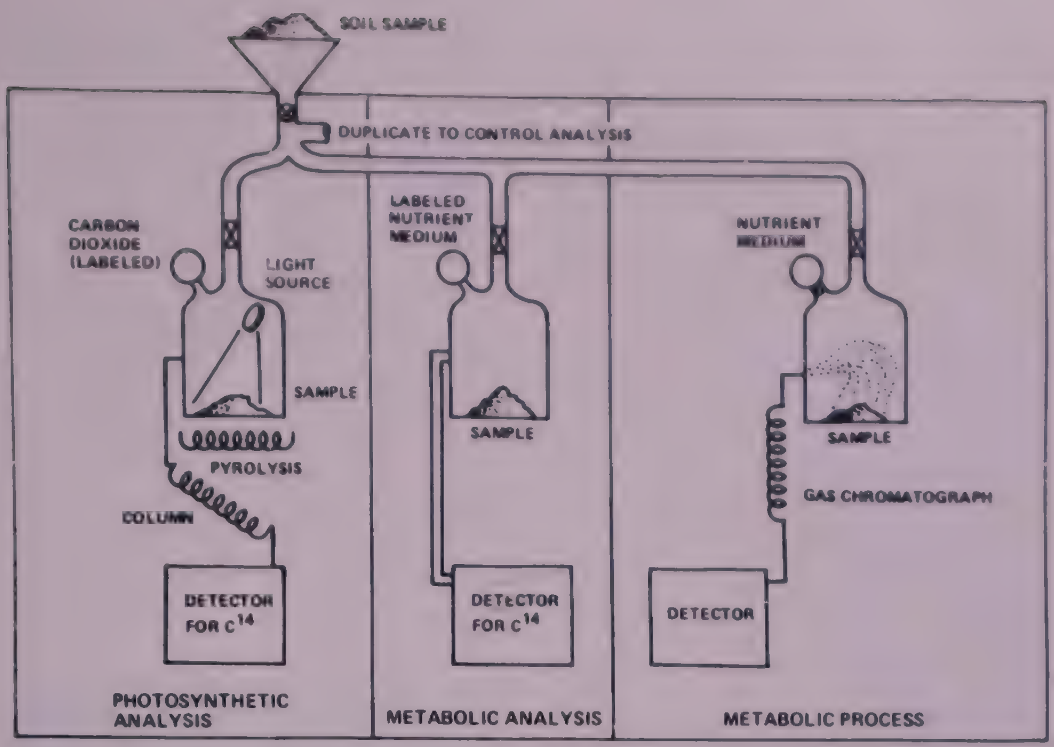
# s?

**From the present understanding of life ng to preclude some forms of micro- missions are moving scientists towards he Tata Institute of Fundamental Re- rocesses in the context of the Viking S.**

Is the evolutionary process a pure chance, or a certainty, given certain environmental conditions ? In the history of living organisms on earth, we find certain species becoming extinct and new species coming up. The survival of any new species depends on the environmental conditions present during its formation. There are certain favourable conditions that have helped in producing organic compounds in the earth's atmosphere. Again, these favourable conditions have been responsible for the evolution of micro-organisms from these compounds. Further innumerable evolutionary processes gave rise to the higher forms of life. What can we call these favourable conditions ? They may perhaps be called 'Resonances'. The system, if it is in tune with nature, resonates and goes to the next stage in evolution. If there is no resonance, there is no evolution.

### Special Compounds

We have seen that life evolved on earth out of inanimate matter. The elements that go to form life occur abundantly in nature and there is no need for any special elements. However, it needs special compounds—long chain of organic molecules—which limits to a large extent the temperature in which life forms may originate. At very high temperatures, these complex life-giving molecules dissociate into simpler elements or compounds. At very low temperatures, even though the compounds may be stable their reaction rates (which are needed for metabolic processes) are very low so that even if life were to exist, it would be in a quiescent form. Also, for biological processes to operate we need liquid water—the universal solvent. Free oxygen is also needed for advanced forms of life that we see on earth.



**A simplified block diagram of the biological experiment package on board Viking lander. All the experiments can be controlled from earth by radiocommand.**

Since the other objects in the solar system are essentially made up of elements in a similar proportion to what exists on earth, the major constraints for the existence of life in other planets is the need for oxygen, water and a narrow comfortable range of temperature. Thus, the possibility of life elsewhere in the solar system depends on the existence of these conditions. It should be noted that these are only the necessary conditions, but they may not be sufficient. There are many other parameters to be satisfied which may make life difficult inspite of the existence of these favourable conditions. However, it is extremely unlikely that life would exist without oxygen, water and the comfortable range of temperature required. Hence, we look for these evidences in other objects, including Mars, in our search for extraterrestrial life.

For a proper understanding of the evolution of life and the possibility of life on Mars, it is worth considering how the solar system—the sun and the planets—originated. The formation of the solar system is still a mystery and no clear cut answer exists. Some think that the planets are a by-product of the process of the formation of the sun (and other stars). Others think they are the result of some catastrophic events like the collision of one star against another. Even though the process of formation of the solar system is uncertain, the time of formation is pretty well known—about five billion years ago. This age is arrived at by dating terrestrial and lunar rocks, as also meteorites. Presumably when a cloud of dust and gas condensed to form the sun due to mutual gravitational attraction, some rings of matter were left out orbiting round the sun. Later they evolved into the earth and other planets and their satellites. Even though the earth itself originated about $4\frac{1}{2}$ billion years ago, the first primitive forms of life probably originated only about three billion years ago, as mentioned earlier.

How does one find the time of formation of life, and the periods of evolution ? Studies of fossils in sedimentary rocks, ocean sediments and certain anthropological and archaeological sites tell us of the time sequence in which various forms of life evolved. Organisms, when they are dead, get deposited in sediments which, due to the pressure of successive layers of

*(Continued on page 6)*

# What is the Fundamental Cause of Life?

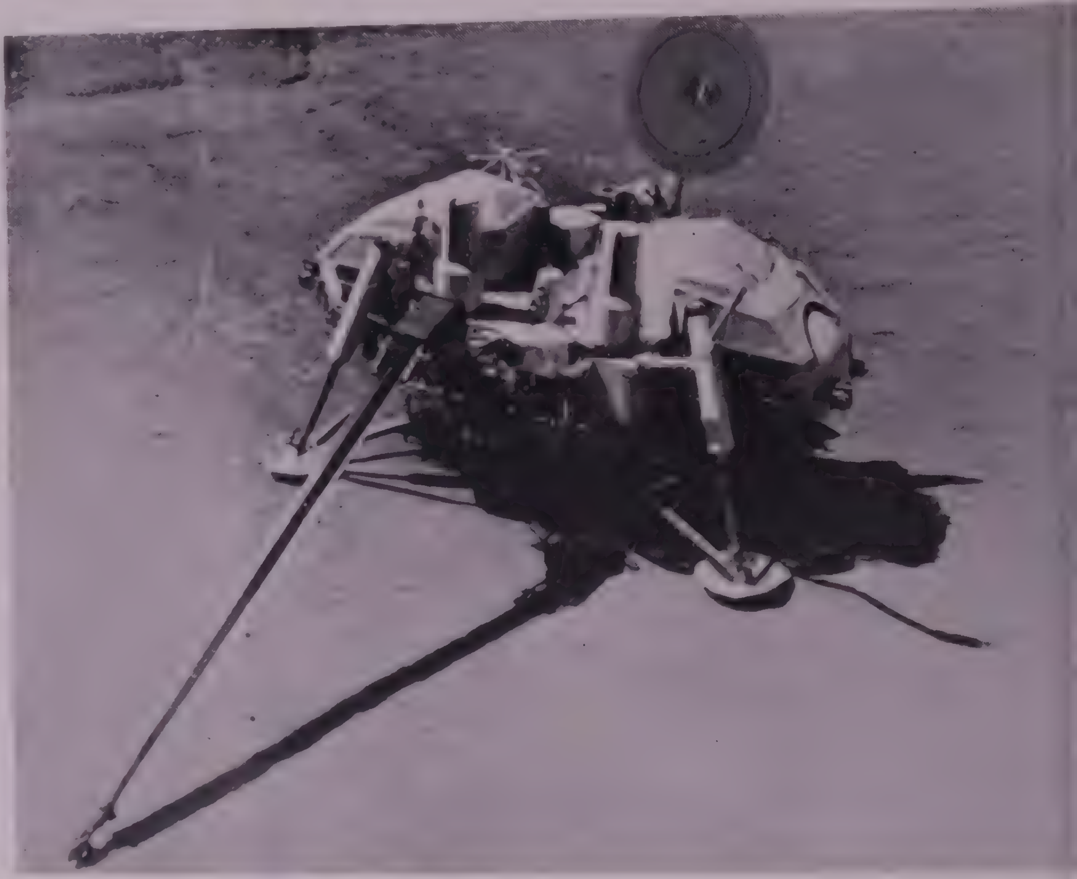
(*Continued from page 5*)

sediments, may turn into rocks. These rock strata and sedimentary layers can be dated by nuclear and stratigraphic techniques. When we find certain species trapped in a rock, say a million years ago we can reasonably conclude that the organism lived during the time. By such detailed studies we know for instance that the first air breathing animals appeared on earth around 500 million years from now. The dinosaurs appeared about 200 million years ago and became extinct about 100 million years ago. The birds began their appearance around 60 million years ago, and the horse another 10 million years later. The modern man—Homo sapiens as he is called, distinguished by his ability to walk on two feet and manufacture tools appeared only 50,000 years ago. All these have been reconstructed from the study of fossil bones and petrified life forms. Thus we find that even if conditions were to exist in other planets it takes an enormous (billions of years) time for the evolution of very advanced forms of life.

### Martian Atmosphere

Different planets in general may be in different evolutionary stages depending on their geological history. In principle, one may expect anything, from micro-organisms to advanced forms of life in other planets. From an analysis of atmospheric constituents and temperature conditions of planets of the solar system, it appears that advanced forms of life similar to terrestrial life may not exist in any of them. However, we cannot rule out some forms of micro-organisms or some entirely different forms of life on these planets (See *Nuclear India*, Vol. 13, No. 5, pp. 4-8).

Will Mars have at least some primitive forms of life? From our present understanding of life processes and the evolution of life on earth, as described earlier, there is nothing to preclude some forms of micro-organisms on Mars. The Martian atmosphere contains about 95% carbon dioxide, 2.3% nitrogen and about 0.3% oxygen. Traces of water are also present. The Martian soil, like terrestrial soil, must have other minerals important for life processes. The temperature in the equatorial region of Mars could go upto about 30°C in summer. However, even in summer the night temperature goes below —50°C. In addition, the extremely thin atmosphere of Mars (less than 10 millibars pressure compared to earth's 1030 millibars) lets in lethal ultraviolet rays from the sun and charged particles from space. Can life exist in such an environment?



**Viking lander.**

It has been known that certain organisms, like blue green algae, have tolerance to extreme conditions. They have been found in Antarctic ice as well as in hot spring waters. In a laboratory simulated atmosphere of Mars, bombarded with ultraviolet radiation, certain micro-organisms survived. Even on earth, there are the anaerobic plants which live entirely without air. There are also certain kinds of lichens which live under the driest conditions by absorbing traces of water in the atmosphere.

Even though at first sight Mars may not appear to be conducive to life, the above arguments coupled with intelligent guesses give some optimism for the existence of at least some forms of micro-organisms, if not higher forms of life. The Viking landers have not seen any large forms of life such as animals or trees. The landing sites resemble th terrestrial deserts with sand dunes an rocks of various shapes and size strewn all over the landscape. Th orbiters have seen a larger area of th planet which is abundant with crater and volcanic mountains. There ar dried up rivers with tributaries an canyons shaped by geological processe including flowing water. There are als huge cloud formations particularly ove the volcanic mountains. Some of thes mountains are so tall that they appea clearly above the cloud tops. A few of the volcanoes appear to be still active, letting out water vapour and other volcanic gases. There are high winds and ocassional dust storms. All these observations give a remarkable picture of the planet as geologically and meteorologically well alive. Whether it is biologically alive will of course be answered by the Viking lander's automated biological laboratory.

Even though there are a number of experiments in the Viking spacecrafts to study the Martian atmosphere and soil, there is nothing to surpass the complexity of the automated biological laboratory.

The lander has a long scooper which digs Martian soil and transports it to various experiments for analysing physical, chemical and biological properties of the soil. The miniature biological laboratory of the Viking lander has three experiments to determine whether the Martian soil has any micro-organism. The experiments look for photosynthetic activity, metabolic processes (utilisation of nutrients) and for respiration (release and absorption of gases typical of the life process) of organisms, if any, in Martian soil. The complexity and sophistication of the biological laboratory can be seen from the fact that it has a computer, a number of ovens, nuclear counters, a lamp to simulate sunlight and a gas chromatograph. It has also over 40 miniature valves to control the flow of gas and nutrients, another 40 temperature control devices and a number of electronic devices with about 22,000 transistors and nearly 20,000 other electronic elements. (*See fig. on page 5.*)

In the photosynthesis experiment the Martian soil is warmed in an incubator and exposed for five days to radioactive carbon dioxide (containing carbon-14) in the presence of a xenon arc lamp to imitate the sun. If the organism were to utilise the carbon dioxide for photosynthesis (similar to terrestrial life), the soil will become radioactive with carbon-14. After the incubation period is over, the chamber is evacuated and the sample heated to 700°C. If the Martian organisms of the expected type are present in the soil, the gas released during the heating will be radioactive. This will be detected by a nuclear radiation counter.

The second experiment uses labelled nutrient medium. If the nutrient is absorbed by the organism, it may release radioactive carbon dioxide. This release of carbon dioxide can again be tested by a nuclear radiation counter.

In the third experiment release of gases typical of life processes is tested using a 'gas chromotograph'. In this experiment Martian soil moistened by water rich in nutrients like amino acids is incubated for about two weeks in a sealed cup. At regular intervals of time the gas surrounding the soil sample is allowed to pass through the gas chromotograph which can detect changes in concentration of gases as small as one part in a million. A change in the composition of the gas could give some clues to the presence of biological organisms in the soil.

The experiments will be repeated a number of times to make sure that the results are reproducible and not due to any faults in the instruments. There are also control experiments in which the signals should be absent.

## Super Oxides

Surprisingly all the three experiments have given positive signals denoting the possible presence of micro-organism on the surface of Mars. For instance, the experiment measuring the conversion of radioactive labelled nutrient to (labelled) carbon dioxide showed an initial rapid burst of activity but died down soon after. In the gas release experiment, the soil was found to release a large amount of oxygen when moistened with water (even before the nutrients were added). This release of oxygen could be due to living organisms, but chemical reaction of an inorganic nature could also be partly or wholly responsible for the evolution of oxygen. oxidising chemicals such as super oxides could produce the results seen in both experiments. Release of radioactive carbon dioxide in the labelled nutrient experiment would continue for about 10 days if microbes were present in the soil, whereas a chemical reaction would stop after an initial burst of activity. In the Viking-1 test, the gas stopped evolving after about three days somewhat in-between pure chemistry and biology.

The presence of super oxides in the soil would be poisonous to life but it is likely that organisms may survive deeper below the soil where the chemicals would not be formed.

The pyrolytic release experiment points to the possibility of the biological process on Mars better than the other two experiments. Unlike the other experiments, the observation would not be the result of oxidation ; in fact they need reducing agents such as hydrogen and carbon. The signals from the instrument correspond to the presence of about 1,000 bacteria cells in the sample. Whether it is truly biological or not will be known after the results of the control experiments (and more detailed analysis) are available.

In summary, the Martian soil behaves in a strange way unlike any terrestrial soil. Its behaviour is complex and puzzling. It could be biological. But this needs confirmation. However, search for biological compounds in the soil has not given any positive results, One would expect some amount of biological material on the soil if the signals from life detection experiments are due to life processes. The lack of any signal due to biological compounds adds to the mystery of the life detection experiments.

Recent analysis by Viking-2 also gives similar results as that of Viking-1, deepening the mystery.

Man has understood to a large extent the properties of inanimate objects. Except for its ultimate origin, we now know fairly well how matter has evolved over billions of years. We have also understood the basic structure of matter in great detail. Regarding life, advances in biological sciences have explained many questions about life processes which originally belonged to metaphysics. Still there are two basic questions regarding life : (1) What is the fundamental cause of life ? (2) Is life unique to earth ? It is a strange coincidence that when the Vikings are analysing the Martian soil to get an answer to the latter question, Dr. Khorana and his colleagues have

(*Continued on page 8*)

# India Has Rich Experience in Nuclear Waste Management

(*Continued from page 3*)

tensive research and development work is continuously carried out with a view to ensuring safety and self-reliance through maximum utilisation of indigenous technological capabilities. Even in locations with highly unfavourable environmental conditions, our record of operations has proved the effectiveness of the processes developed and the safety of operations undertaken. While we have worked on the basis of 'as low a discharge as possible' as a practical reality, our current efforts are directed towards the concept of limiting discharge of activity to the environment. During the last year, we have been engaged in the construction and setting up of a facility for solar evaporation of liquid wastes which perhaps could be one of the first such applications in the world.

Of special significance in this context is our effort in the field of management of high level wastes produced from our fuel reprocessing facilities. We have had over a decades experience of storage of high level liquid wastes in specially designed and constructed storage tanks without any incident. We recognise of course that tank storage can only be an interim solution. We are, therefore, at present setting up a waste immobilisation plant for fixation of high level liquid wastes in a glass matrix. When completed, this plant would be one of the first large scale facilities of its kind. We are also planning facilities for, initially, interim storage and ultimately, disposal of the solidified high level radioactive wastes in a favourable geological formation.

In conclusion, may I stress the need, in particular of enlarging the scope and range of the Agency's programme of assistance to the developing countries with allocation of relatively more resources in the future. This is essential so as to accelerate and reinforce national efforts in these countries to harness nuclear technology for the much-needed economic progress. The Agency has an important international responsibility in this field and I have no doubt that it will meet its obligations with a sense of dedication it has always displayed. On our part, we would like to pledge our continuous support and assistance to the Agency's endeavours. ●

# TIFR Demonstration of RECON System

(*Continued from page 1*)

logy to scientists, engineers, technologists, doctors etc. to enable them to have almost instant access to vast stores of information held in data bases located at global distances. For this project, the Ministry of Communications laid a data circuit capable of transmitting information at a speed of 4,800 bits per second from the Overseas Communication Service building to the TIFR which enabled a link-up with the Frascati data centre near Rome, using the satellite communication link between Bombay and Rome during the period of the demonstration.

Scientists and technologists working in various R & D establishments, academic institutions, government departments and industries, information scientists, librarians etc. were invited to participate in the programme. The demonstration made it possible for the participants to have immediate access to information stored in ESRIN, Frascati. They were able to operate the keyboard of the terminal and scan relevant information on the video screen and get a print-out.

The operation of the system is based on interactive on-line dialogue. The terminals are fitted with a video display screen with a keyboard and on-line printing devices. A user can enter the system by typing the prescribed commands and the words representing the topics to be searched. ●

### Nuclear Physics and Solid State Physics Symposium

The Nuclear Physics and Solid State Physics Symposium, organised under the auspices of the Department of Atomic Energy, will be held this year at Gujarat University, Ahmedabad during December 27-31.

The deadline dates and other relevant information are:

| | |
|---|---|
| Abstracts … … | October 18, 1976 |
| Papers for Rapporteuring … | November 24, 1976 |
| Other Papers … | December 1, 1976 |

Abstracts and papers must be sent to the respective secretaries :

| | |
|---|---|
| Nuclear Physics: | Dr. S. K. Kataria Nuclear Physics Division, Modular Laboratories, Bhabha Atomic Research Centre, Trombay, Bombay 400 085. |
| Solid State Physics: | Dr. K. R. P. M. Rao, Nuclear Physics Division, Modular Laboratories, Bhabha Atomic Research Centre. |

# Life on Mars?

(*Continued from page 7*)

synthesised a working gene which wi
be useful in answering the first question. Detection of life on Mars an
its properties may also give som
clues for understanding the nature c
life. Is life just an assemblage of som
long chain of organic compound
controlled by the DNA (dioxyribc
nucleic acid) on a purely materialisti
basis (somewhat analogous to a machin
coupled to a computer) or is it something more than that? On a secon
reflection, we may come to hold th
view that life is no more mysteriou
than the other matter we see aroun
us. How did they come into being
The mystery of the presence of matte
and the mystery of the origin and natur
of life are probably inter-related.

A symposium on **Operating Experience of Nuclear Reactors and Power Plants** organised under the auspices of the Department of Atomic Energy will be held at the Bhabha Atomic Research Centre, Trombay, Bombay during February 7-9, 1977. Detailed information can be had from : Shr Rajendra Narain, Scientific Secretary Technical Programme Committee, CIRUS Bhabha Atomic Research Centre, Bombay 400 085.

Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India, Chhatrapati Shivaji Maharaj Marg, Bombay 400 039, and printed by him at G. Claridge & Co. Ltd., Bombay 400 001.

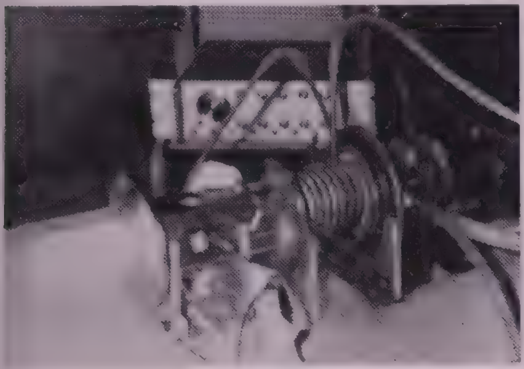
Registered No. R. N. 9002/6

# NUCLEAR INDIA

VOL. 15. No. 3 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY NOVEMBER 1976

# High Temperature Argon Plasma Unit at BARC

A PLASMA wind tunnel facility for obtaining a high temperature flowing gas environment has been built in the Plasma Physics Section of the Bhabha Atomic Research Centre. The facility is useful for testing properties of materials at high temperatures and different flame conditions. Since conventional furnaces are limited in their temperature and environment, the facility becomes useful for a large range of test conditions. The plasma generator is similar in principle to the D.C. plasma torches for metal cutting and ceramic spraying developed earlier.



**The argon plasma jet at BARC.**

The facility uses a 100 KW plasma jet, which generates Argon plasma at a temperature higher than 15,000 K. The gas then passes through a mixing chamber lined with zirconia ceramic, where gases or seeding materials may be added to the plasma for obtaining desired properties in the flame. Thus, it is possible to control the gas temperature and produce the desired chemically inert, active or corrosive flame conditions. By seeding the gas with alkali metals like caesium or potassium, the gas can be made electrically conductive even at lower temperatures.

The unit is capable of giving a flame temperature of 3,000 K at an Argon flow rate of 300 litres/min. The flow velocities may range from 10 to 100 m/s, and heat fluxes upto 300 $W/cm^2$ can be achieved. The system is designed for continuous operation, thus permitting long duration testing of materials. It has been used for testing the thermal properties of material required by ISRO for nozzle lining in satellite launch rockets.

**Physical Reality—Is There Any Other ?**
Dr. R. Ramanna discusses on pages 4-8

This plasma jet unit has been set up primarily for conducting studies on MHD plasmas and materials being developed for MHD power generation at BARC. It can also be used for evaluating high temperature materials required in the steel, cement and thermal power industry. ●

## *Power in Tranquility*

**The Rajasthan Atomic Power Station at Kota.**

# Ion Impl
# Vast

EVER since the Bronze Age, man has been making a variety of alloys of metals. Alloys can be made only with metals that mix with each other. For example, a mixture of chromium, nickel and iron gives stainless steel, and a mixture of copper and zinc makes brass. But an alloy of copper and iron cannot be made because they are not miscible. Or, to take an extreme case, one can never make an alloy of argon (which is an inert gas) and iron.

However, ion implantation can make 'alloys' of such incompatible materials within limits. In the ion implantation process, very high energy argon atoms are driven into the iron base, or in other words, argon is implanted into iron. The argon atoms penetrate into the iron to a small depth, and having lost their energy in collisions, lodge in the iron to form a material which has new properties. Since the depth to which the argon penetrates is very small, only surface alloys can be made through this method. But these surface alloys are often extremely hard and very resistant to corrosion.

After bombardment, most of the element that is implanted stays in the base even at temperatures of 600 to 700°C. In some cases where the two elements do not mix, precipitation in the form of clusters does occur on heating. But at lower temperatures, say upto 300 or 400°C the surface alloys are stable.

Some work has been done at BARC on surface alloys. An example is nitrogen implantation in steel. Stee is usually hardened by heating in a nitrogen atmosphere. It is said tha in the times of the Crusades, the swordsmiths hardened the swords o the Crusaders by plunging the red hot blades into horse urine, which contains a lot of nitrogen. So nitrogen was implanted into stainless steel to increase the latter material's hardness. In this way one can ge a relatively soft material which car be worked easily enough but which has a very hard surface.

**Dr. Nataraja Sarma**
Nuclear Physics Division
Bhabha Atomic Research Centre

In another experiment, glass was exposed to a beam of atoms from th ion implantation facility at BARC This resulted in a change of its structure near the surface, and its refractive index increased significantly This glass has very interesting applications; for instance micro lenses an micro-prisms and other miniatur optical devices can be made in thi way. There is also a possibility c making an optical transmitter— transmitter using light instead c radio waves as carrier waves for broadcasting set. The light is generated by a microlaser and it is expected that the entire transmitter wi be smaller than a matchbox.

Electronics firms in the U.S.A. ar Japan have very elaborate faciliti

## Miniature Nuclear Battery

**This miniature nuclear battery—only 35 mm long and 15 mm in diameter has been developed in Britain by the United Kingdom Atomic Energy Authority. It uses heat from the radioactive decay of a small quantity of plutonium-238 to generate electricity in a miniature semi-conductor thermopile (an apparatus formed of rods of special metal put together in parallel).**

**The design of the battery, including the encapsulation of the plutonium, ensures that there is no hazard either from radiation or from the escape of radioactive material. It has a design life of 20 years and has been applied in the first instance to implanted heart pace-makers that bring a new lease of life to thousands of people suffering from certain types of heart trouble.**

**The technology for the battery has been developed over a six-year period during which time it has been subjected to stringent, internationally agreed safety standards to ensure that it will withstand the most severe accident, fire, impact—or even cremation.**
*(Courtesy UKAEA)*

# tion Technique Opens ta of New Alloys

to make ion implanted circuits. Using ion implantation, they put something like a hundred thousand components on a single small silicon chip. These very complex circuits are used in the small but sophisticated calculators and digital watches. In India not much has been done in this field as it requires very large investment, but some solar cells have been made at BARC by implanting gallium into silicon. These cells are reasonably efficient.

### Great Advantage

To make a transistor or rectifier, or an integrated circuit— which is a small component in a radio set or computer—boron or phosphorus are diffused into a selected area of a silicon chip. In the conventional process of diffusion, the chip is heated in a boron atmosphere and the boron seeps in. The smallest dimension onto which the boron can be put in is about 5 to 10 microns (a micron is a thousandth of a millimetre). In ion implantation, this dimension is defined to about a tenth of a micron. So ion implanted components are about ten times smaller than conventional components. In other words, one can put in ten times as many components in the same area as done through conventional methods. Secondly, the depth of penetration is defined exactly and therefore the circuits are more reliable.

In the beginning this process was expensive but as the technology has now developed considerably, the cost has come down. That is one reason why electronic calculator prices are much lower than they were a few years ago.

The great advantage of ion implantation is that alloys of any two of the ninety-two elements which exist in nature can be investigated. This means 4,186 combinations. Two or more elements can also be implanted; besides, the proportion of the element that is implanted can also be altered. So, a vast open field is available in material science. There is a second advantage. The exact depth to which the atom can penetrate is known—it depends on the energy. One can therefore determine not only the area to be implanted, but also the depth to which it should be implanted accurately, to within ten thousandth of a millimetre.

There are also some disadvantages. One of them is that the atoms penetrate only a thousandth of a millimetre and therefore only the surface properties of the material can be treated; but in most cases this is what matters. If the properties of the bulk material are to be changed, alloying methods have to be used. The second disadvantage is the cost. At the moment ion implantation is more expensive than other methods, if they are at all possible for achieving the same results. A large part of this cost is involved in just taking the base into and out of high vaccum. High vacuum is necessary as otherwise the air particles will scatter the beam away from the target. New methods have to be developed to tackle each problem to bring the cost down.

It must also be added that if after implantation the material is heated to about 500°C, it regains its original structure.

The machine to produce high energy atoms of various elements has been used by nuclear physicists for almost fifty years. It consists of a source of charged atoms or ions, a high voltage—of hundred or two hundred thousand volts—which accelerates the ion to high speeds, and a magnet to separate out the atoms which are to be implanted, and to reject the rest. At BARC, such a machine has been made for around Rs. 4 lakhs. A similar machine if imported would cost around Rs. 20 lakhs. The equipment is not large; it stands about three metres high and occupies an area of about three metres by two metres. While developing this machine a very compact high voltage supply was also built which will be useful in the electrical engineering industry.

### Ion Implanted Circuit

While the atoms go into the material, the atoms of the base or target get knocked around and the structure changes. This causes swelling or creep in the components of a reactor. This phenomenon is very important when the design of nuclear reactors is being considered. Ion implantation methods can be used to study such radiation damage phenomena. The advantages of radiation damage are also there; the refractive index change in glass is one such result.

The electronics industry will be using ion implantated circuits soon. This is being investigated in cooperation with other laboratories. Application in other industries in India is slow because these new processes require long experimentation so that exactly reproducible results may be obtained. The process has also to be scaled up to production level for which a new machine has to be built for a particular job. There are several requests to BARC from industries for solving some of their problems. BARC for example, is investigating if corrosion in certain electrical switchgear components can be reduced by ion implantation. An attempt is also being made to harden the surface of aluminium by implanting titanium in order to reduce wear of a vital part. Another interesting application is the production of fully transparent conducting glass. ●

# Physical Reality —
# Is The

**Dr. R. R**

Director, B

AT the very outset, I would like to say a few words on my competence to speak on this subject. For one thing, many of the ideas expressed here are certainly not new. At best it is perhaps the order in which they are expressed that may be a contribution, if at all, to the subject. The reason why I have chosen this particular topic is only because I have spent a greater part of my working life with scientists here and abroad and feel that science by itself does not, and should not claim a right to solve all the problems of the world. And hence, we discuss physical reality essentially to understand a reality of a higher order which encompasses physical reality.

What is reality is a question that has been asked from time immemorial and no clear answer is still available. However, a scientist, due to the constraints applied to him to quantify every entity that he has to deal with, has to have a working definition of reality and this we shall call "physical reality". Physical reality is determined solely by our ability to observe mainly through our sense organs. We may be able to improve our capacity to observe and above all quantify it by means of various gadgets called instruments. It should be noted that however good our instruments, the final assessment of reality has to be carried out by the brain itself. Only the inputs from the sense organs go to define the concept of reality inside. We may then develop secondary quantities based on fundamental measurements like mass, time, distance, other complicated quantities to explain in as simple a manner a large set of physical observations. In this process, we may also classify all physical objects by observation into states of matter *e.g.* solids, liquids, gases, and set about criteria for making these classifications.

It is in this connection that I would like to refer to the 17th century treatise on a Primer of Logic by Annambatta called 'Tarkasamgraha', which is essentially a concise treatise on classification. In this particular approach to classification, the criterion is not entirely physical, but psychological and sociological. I quote here (*see panel, p.5*) three stanzas as translated by the late Kuppuswamy Sastri of Madras. I hesitate to change the translation, coming as it does from such an eminent man, but I may be allowed to replace some of the words with those used in modern scientific terminology and examine the resulting classification just out of curiosity.

It is not my intention to fall into the usual trap of claiming that everything known in modern physics had already been discovered in the past. But I feel that 17th century India was in fact ready for the development of modern science as we know it today. The failure of this development must be attributed to other causes. The aim of quoting Annambatta here is to show that it was realised long ago that reality is established only partially by observation, but complete reality requires many other parameters of description. In Annambatta's scheme of classification, reality is not confined to physical reality alone (though he gives no criteria for quantifications), but includes attributes such as soul, pleasure, pain etc. *i.e.* the overall subjective effect of the object on the person. We will return to this enhanced definition of reality and as we shall see later, modern science does not exclude these possibilities.

IN modern classical physics, we believe we have understood the structure of the system and established its reality if we know at any given time all the positions, masses and velocities of its constituent particles. With the few basic laws of physics, *e.g.* Newton's laws, Maxwell's equations etc. we can predict its subsequent behaviour with great accuracy and therefore feel we have understood all about the material world. The classicist will admit that some of the problems are complicated due to computational difficulties and the laws of probability will have to be invoked. However, the basic assumption in this approach, as far as the observer who has established the position, velocities etc. is concerned, is that his intervention does not influence the phenomena and if it does so, he can correct for it, in principle, quite accurately. It proved to be a very successful approach before the advent of atomic physics and it is this that led to the 19th century belief that all is known of the physical world and any subjective elements in it or "the bifurcation of nature into the physical and mental world" can be explained away in due course on these classical foundations.

Many of us have seen in our lifetime the complete collapse of these ideas. An observer, after all, is like an inquisitive child who tears down objects in front of him to see what is inside. In a somewhat similar but organised manner, we have collected a tremendous amount of facts concerning the world of atoms and nuclei. In explaining the properties of these systems, it became clear early in th stage of these investigations tha physical reality as established purel in the classical sense does not lead t an absolute picture of what actuall exists. But the picture that emerge

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*Lecture delivered at the Centenary Convention of The Theosophical Society, Madras, on 29 December, 1975.

# y Other?

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is dependent on the consciousness and hence the interpretation of the observer. All this arises out of the probabilistic nature of the new mechanics and its consequent indeterminacy. We are inevitably led to this conclusion in any epistemological discussion on quantum mechanics. All efforts to bring these discussions within the framework of classical epistemology has been in vain.

We now examine briefly and in a general way the nature of the problem posed by quantum mechanics. It should be noted that the difficulties of interpreting quantum mechanics are not philosophical in nature but arise from the very formulation of its foundations. However, we note that in spite of the vagueness of the foundations, it is amazing how much of nature can indeed be described in mathematical terms.

In quantum mechanics, since it claims to explain everything, in principle, of Nature, measurement is inseparable from that being measured, the instrument with which it is being observed and the observer. All these form a single entity and will have to be described in quantum mechanical terms *e.g.* wave functions. But since measurement in quantum mechanics is possible only by an interaction with that which is observed, the effect of the observation on the subject cannot be neglected and it is this that leads to several paradoxes unless we make assumptions on the existence of human consciousness and assert

(*Continued on page 6*)

| *Sanskrit* | *Transliteration* | *Translation A* | *Translation B* |
|---|---|---|---|
| **Verse 2** | | | |
| द्रव्य | Dravya | Substance | Matter |
| गुण | Guna | Quality | Property |
| कर्म | Karma | Activity | Dynamics |
| सामान्य | Samanya | Generality | Intersection with sets of properties of all other matter. |
| विशेष | Visesa | Particularly | Disjoint set of properties with respect to other matter. |
| समवाया | Samavaya | Inherence | Internal structure |
| अभावा | Abhava | No existence | Non-material form, Null set |
| **Verse 3a** | | | |
| पृथ्वि | Prithvi | Earth | Solid |
| आप | Aapa | Water | Liquid |
| वायवा | Vayu | Air | Gas |
| तेजो | Tejo | Light | Radiation |
| आकाश | Akasha | Ether | Ether |
| काल | Kala | Time | Time |
| दिग | Dik | Space | Space |
| आत्म | Atma | Soul | Soul |
| मनांसि | Manamsi | Mind | Mind (consciousness) |
| **Verse 3b** | | | |
| रूप | Rupa | Colour (Physical Attribute) | |
| रस | Rasa | Taste (PA) | |
| गन्ध | Gandha | Smell (PA) | |
| स्पर्श | Sparsa | Touch (PA) | |
| संख्या | Sankhya | Number (PA) | |
| परिमाण | Parimana | Size (PA) | |
| पृथक्त्व | Prthktva | Separateness (PA) | |
| संयोग | Samyoga | Conjunction (PA) | |
| विभाग | Vibhaga | Disjunction (PA) | |
| परत्वापरत्व | Paratvaparatva | Proximity (PA) | |
| गुरुत्व | Gurutva | Weight (PA) | |
| द्रवत्व | Dravatva | Fluidity (PA) | |
| स्नेह | Sneha | Viscidity (PA) | |
| शब्द | Sabda | Sound (PA) (capacity to vibrate) | |
| बुद्धि | Buddhi | Cognition (Subjective Attribute) | |
| सुख | Sukha | Pleasure (SA) | |
| दु:ख | Duhkha | Pain (SA) | |
| इच्छा | Iccha | Desire (SA) | |
| द्वेष | Dvesha | Dislike (SA) | |
| प्रयत्न | Prayatna | Volition | |
| धर्म | Dharma | Merit | |
| अधर्म | Adharma | Demerit | |
| संस्कारा | Samaskara | Tendency | |
| **Verse 3c** | | | |
| उत्क्षेपण | Utksepana | Upward motion | Directed motion (vector) |
| अवक्षेपण | Avaksepana | Downward motion | |
| अकुंचन | Akunchana | Contraction | |
| प्रसारण | Prasarana | Expansion | |
| गमनानि | Gamanani | Going from place to place | } random motion |

(*Continued from page 5*)

that a quantum object exists only if it has been observed, otherwise it exists potentially in a probabilistic sense and not in reality.

The nature of the epistemological difficulties is best described by the so called "Cat paradox" of Schrödinger. Consider a cat enclosed in a box not observable from outside. In the same box a random event over which we have no control triggers a hammer which breaks a bottle containing prussic acid or some such poison. The random event is caused by the decay of some radioactive atom, which has a probability that in one hour an atom will decay and trigger the event. Quantum mechanics says that the wave function describing the process will consist of parts in which the live cat and dead cat are mixed. Now this is a paradox since the cat can be either alive or dead.

There have been several efforts to explain away this paradox but the following two views bring forth the dilemma modern physics finds itself in:

(1) The 50% chance that the cat is dead or alive means that if we carry out this experiment with a large number of cats (a most cruel experiment to perform) we would find that half the cats are dead or alive. The total wave function only gives the probability that it will collapse to a single state corresponding to a cat being dead or alive. No further questions are asked on how an observation finally decided the outcome of the experiment as it is not considered to fall within physical analysis, even if the event is one that cannot be repeated more than once.

(2) While quantum mechanics gives the probability that the cat is dead or alive only, it is the intervention of the observer alone that can decide whether the animal is dead or alive. Since the observer is also a physical object and should be a part of the total system *i.e.* the total wave function, his final decision not to continue a probabilistic argument but terminate it by a decision is due to the fact that he has a non quantum mechanical consciousness capable of assessing situations and making final decisions. This is unique to human beings in spite of the fact that his body is made up of quantum mechanical particles, and indeed the eye almost detects even individual photons.

In (1) the dilemma is overcome by saying it is not relevant for physics.

# *Physical Reality—*
# *Is There Any Other*

(2) states that the very formulation of quantum mechanics requires an observer with a consciousness indescribable in present-day physics. Whether in (2) you use consciousness, spirit or God is a matter of choice, but what is important is that such words are inescapable in fundamental physics.

I have included a few details on the epistemological problems posed by quantum mechanics, because even at the purely physical level one has to concede that the mind of man must intercede to make the final decision irrespective of all instruments we may have at our disposal, or merely say we do not know and decide not to ask unnecessary questions. This being so at such a fundamental level, we should not be surprised if some persons invoke God to explain other mysteries of the world.

We are now extremely confident about the power of physical methods to analyse atomic phenomena. We also have enough evidence that uni constituting life are also made up the same atoms. Where then, an how does the manifestation of li appear starting from the same buil ing blocks of which we have cons derable information? Why is it th a set of atoms which are for all pu poses inanimate, form themselves i to complicated molecules to exhib fantastic properties such as

(a) Genetic replication of identic units but of unbelievable com lexity, and

(b) integration of molecules in thinking beings especially lik man, where he has a capacity t ask questions about himsel Even in the lower species, th capacity to transmit informatio genetic or otherwise, from o to another cannot easily be e plained away on a purely physic chemical basis.

To me it seems that the number chemicals, hormones etc. required express ideas, react to situations a communicate with one another b tween living systems are limited number or even countably infini but the number of possible huma reactions are very much more—pe haps even uncountably infinite in th mathematical sense. You recall he that in mathematics we can prove th there are not sufficient integers rational numbers from 0 to ∝ to cou even all the points on a continuo straight line.

There have been great advances biology in recent years and new d coveries have greatly enhanced o understanding of the relation betwe he micro bio-world and the macro bio-world. In pure physics, exact duplication of the species is a common and well understood phenomenon, and is called crystal growth and though we are going from a state of disorder to a state of order, there is no contradiction of the famous 2nd law of thermodynamics of which we will have something to say later. This law states that a system always proceeds from order to disorder provided no energy is supplied to the system from outside. It seems that the 2nd law is well preserved even in the case of processes where biological order is being enhanced by replication, as the energy balance is still maintained. It is for this reason that biologists believe replication may, in principle, not require any new laws for its explanation. There are many scientists, mostly men of biology, who feel that all biological activity can eventually find a physicochemical explanation based on quantum mechanics. But that it can coexist with a theory which asks for the existence of an unique human consciousness is difficult to accept, unless we come to the same conclusion as do the mathematicians who demonstrate that if one starts asking questions about oneself there can never be answers to some of them. A rigorous formulation of this mathematical limit on decision is called Godel's theorem. It is in these limiting cases that we can say that God is involved—an easy and old explanation, compared to having an uneasy feeling of never being able to explain certain things.

MUCH of physics is based on the two laws of thermodynamics. The first law is the principle of the conservation of energy which states that energy is neither created or destroyed and is borne out by all observations done hitherto. It is only during very short periods of time, of the order of $10^{-24}$ sec. where we cannot say anything about the principle as it is impossible to verify it due to limits set by quantum mechanics. The second law is a more controversial one. While without it we cannot explain phenomena connected with the macroscopic world, its very existence assumes a certain assymetry of nature. It states that in a system by itself, energy can be transferred from one form to another only in a particular direction. There are several versions of this statement, one of which we have referred to earlier in terms of order and disorder, but basically it is a statement concerning the reversibility of physical phenomena. While the law is fully verified in microscopic physics, it is a bit of an embarrassment in the macroscopic world and, in an artificial way, sets a dividing line between the microscopic world where quantum mechanics laws are supreme and the macroscopic world which is usually well described by classical principles. Even the early founders of thermodynamics had noted that the 2nd law could break down in the presence of certain subjective agencies. For example, if we have a box full of molecules at a given temperature T, the velocities of the molecules have a special distribution which depends only on the temperature. If, however, we have 2 holes in the box, and a subjective agency is able to stop all fast molecules going through one hole and allow only the fast ones through the other, it is possible to have two boxes with molecules at different temperatures and in principle get work out of it in contradiction with the 2nd law. It has, however, been shown that purely by physical methods with non-subjective agencies, the energy needed to separate the molecules is equal to what one can get out of it by the separation. If, however, the separation is carried out by a subjective agency, in principle it is possible to violate the 2nd law, and the agency in this case is called a "Maxwell Demon" after the scientist who first proposed it. Though we have as yet not found such a demon, it seems tempting to associate a Maxwell Demon in the replication of biological cells, especially if we find that their complicated structure and uniqueness cannot be explained by any other way.

Recently, scientists have been looking deeply into the origin of the 2nd law of thermodynamics as this great principle of physics which sets limits as to what can or cannot be done in thermomechanical processes seems fully verified in all macroscopic physics. Reversibility, however, seems to be freely possible in elementary nuclear reactions questioning the universal validity of the 2nd law. This situation has made many scientists ask the question whether the 2nd law and paradoxes of quantum mechanics are merely created by our subjective associations with matter.

As we shall see later, this question of subjective association is a very relevant one. In the various versions of the formulation of the 2nd law, it can be stated in terms of a physical quantity called 'entropy' or a subjective quantity like "information". The second law now reads as follows: "In physical processes entropy tends to a maximum". Synonymously, increase of entropy implies increase of disorder. In a strictly logical manner, we can also connect this quantity called entropy with information about a system. Increase of entropy is related to decrease of information about a system. Recently, Dr. Rajendra Bhandari of the Raman Research Institute has made a deep analysis of these problems and comes to the following conclusions and I quote from his as yet unpublished paper as it is difficult to summarise it with any advantage.

"We have tried to present in this paper an unconventional view on the problems of entropy, quantum measurement and irreversibility. This view attributes a role to the observer in determining the nature of observed phenomena, which is far more prominent than hitherto considered necessary or desirable in physics. It

(*Continued on page 8*)

# "Can We Evolve Into Something Higher?"

*(Continued from page 7)*

abandons the common interpretation of our experience in terms of an external world with a given structure, evolving according to fixed laws of time-evolution and an observer who can observe, think and discover these fixed laws and the given structure. 'Phenomena' and the observer are inextricably mixed in this view. It introduces 'levels of perception' as a new element in the description of physical reality. Each of these levels of perception is characterized by a set of concepts and assumptions which determine the totality of states that can be 'seen' by an observer at this level. With a change in the level of perception, he sees a qualitatively different universe (for any reasonable meaning of the word 'universe').

We have argued that a totally concept-free observer cannot see any phenomena, for such an observer sees a universe without any structure. The implication is that it is the observer who imposes a structure on this universe by virtue of his conceptual frame-work. We have shown that such an observer necessarily sees an evolving universe if the second law of thermodynamics is true. The conclusion is that 'structure implies evolution'."

AN immediate question that arises if one accepts the viewpoint of this paper is whether these various levels of perception are attainable by a "human observer". But perception, according to Dr. Bhandari, is the necessary information through concepts that is required before one asks a set of questions about a particular problem and thereby acquires information. "This question perhaps falls outside the purview of physics, but the following way of looking at the problem may be helpful. Let us note that if we accept the more general concept of the 'observer' described above, then for this observer, there is no distinction between mental phenomena like thoughts, feelings, emotions, etc., and physical phenomena like the burning of wood. Both kinds of phenomena are parts of the observer's experience. The identification is useful, however, in one respect. In the realm of mental phenomena we explicitly recognize the impossibility of observation of a phenomenon without disturbing or changing the phenomenon. It is very difficult to observe thoughts without changing them. Further, mental phenomena are known to be phenomena which themselves change as a result of their understanding. For example, if repeated performance of a habitual act by a person is looked upon as a phenomenon, we do allow for the possibility that the person may get rid of the habit by conscious effort in the form of introspection. Now, if there is no qualitative difference between mental and physical phenomena, both taking place in the observer's mind, one must allow for the possibility that the latter may change as a result of conscious effort on the part of the observer. Physical law could be looked upon as habit, only much more deep-rooted, consequently requiring much greater effort to change."

The new idea brought about here is the levels of perception of an observer. The paradoxes or incompleteness of understanding of the universe around us may only be due to the fact that our level of perception is restricted certainly as it is to a classical level in physics. Can we evolve into something higher? The reality in physics is complete to the extent that our perception allows us. As we evolve, not necessarily in the Darwinian sense, a higher reality may become clear to us—shades of Shankara! An insect's level of perception is low and the world may present many paradoxes to it, the human being may be only a little better. Does Advaita show a better way anc is its freedom from mathematics a advantage since all mathematics i circumscribed by our present level o perception. It may also be a disadvantage as philosophical argument tend to be woolly, and much ho air and words by themselves do no increase levels of perception.

I must refer here to recent attempt to identify in a 'scientific' way, if can call it that, the existence of consciousness as exists beyond detectio by the use of the normal sense organs. I must say how strongly feel that these experiments are boun to fail. I am here not referring t demonstrations of magic, materialisation, mass hypnosis etc. to which under different names, large numbers o our gullible people are attracted to but refer to measurement of bloo pressure, pulse rates and other parameters of body functions when subject is exposed to "spiritual" stimuli. These will not show the special indications of consciousness a they are good examples of bad mapping in mathematics. The same effect are produced by a hundred differen causes and hence will tell us nothin new.

In conclusion, I must admit tha the various questions I have referre to have no answers simple or complex, and possibilities of one in th near future seem remote. But the must be discussed more so than eve before. We may even have to ge used to a situation where there ca be no answers at all. I may therefore be forgiven if I have presente these problems in perhaps an ove simplified or highly distorted form.

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Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India,
Chhatrapati Shivaji Maharaj Marg, Bombay 400 039, and printed by him at G. Claridge & Co. Ltd., Bombay 400 001.

**Registered No. R. N. 9002/6**

NUCLEAR INDIA

VOL. 15. No. 4 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY DECEMBER 1976

*Power Reactor Components*

# Coolant Channel Shielding, Sealing Plug Assemblies Made in India

THE effort towards self-reliance in nuclear technology has moved yet another step forward with the manufacture in India of sealing and shielding plug assemblies for coolant channels of the CANDU power reactor.

The country is already manufacturing vital nuclear components such as the reactor vessel, fuelling machine heads and fuelling machine carriages, among other things.

The sealing and shielding plug assemblies fabricated recently are for Reactor No. 2 of the Rajasthan Atomic Power Station.

For Reactor 1 of the Station, complete assemblies were imported from Canada in 1967.

The *shielding plugs* serve to shield the fuelling machine vaults at the two ends of the reactor from radiation emanating from the coolant channel. This assembly consists of several precision machined components which have to work in perfect unison to enable the fuelling machines to operate them during on-power re-fuelling.

The *sealing plug* assemblies are

*(Continued on page 3, col. 3)*

**Coolant channel shielding plugs and sealing plugs made in India for the first time.**

## *Multi-Discipline Techniques Involved In Plugs Manufacture*

THE manufacture of components of sealing and shielding plug assemblies for the CANDU reactors embraces a wide range of disciplines.

Among the variety of operations involved, the following are noteworthy as an indication of the varied demands made on local skill and engineering competence :

- Die forging, heat treating and non-destructive testing of precipitation hardening stainless steel material to make the *seal disc* of the sealing plugs, which is the most critical component of the assembly. Special care is required in formulating the forging process to ensure that the grain flow in the forged component has the required orientation.

**DNA Repair and Its Role In Cancer and Aging—pages 4 & 5**

- Machining the profile of the seal disc to make it strong enough to withstand the very high stresses imposed on it, without sacrificing the flexibility needed to meet the installation and operational requirements.
- "Soft" nickel deposition on the seal disc to serve as a metallic gasket to seal the end fitting openings against high temperature, high pressure heavy water.
- Broaching, as a manufacturing process, is specially suited for the production of a large number of components having intricate shape and close dimensional tolerances. When the manufacture of these assemblies was

*(Continued on page 2)*

MYSORE-2A

# Breakthrough in Stainless Steel Nitriding Technology

(*Continued from page 1*)

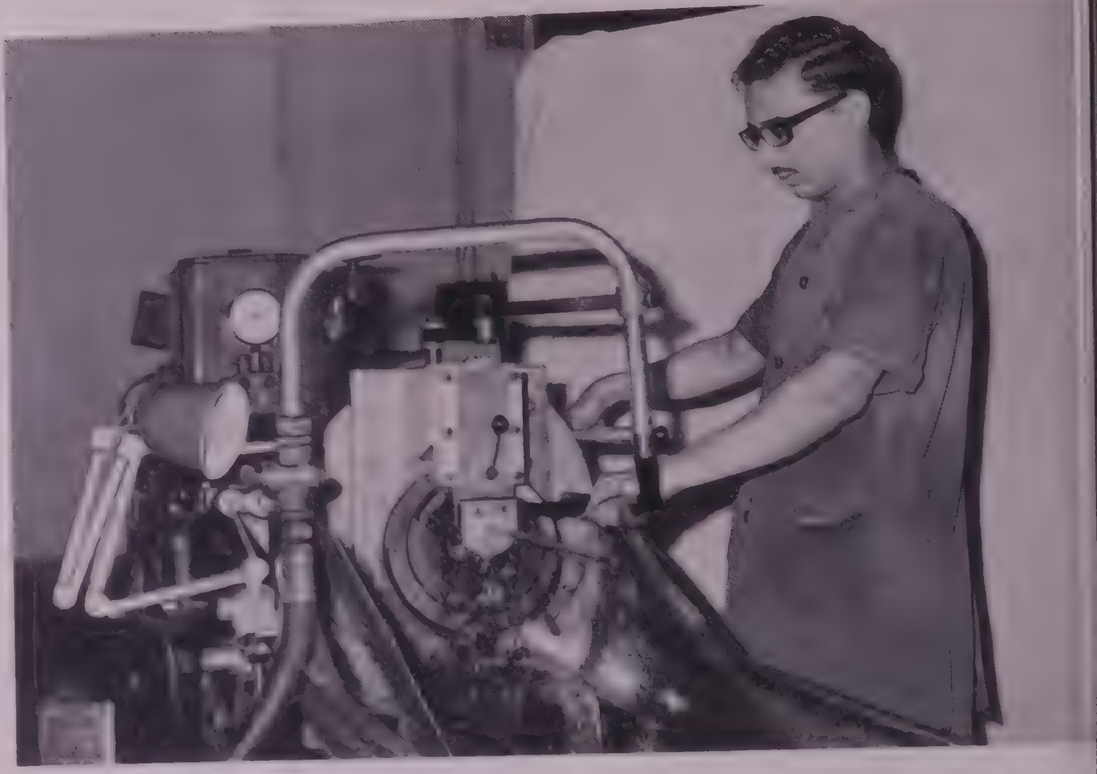
taken up, broaching as a manufacturing method had not been used in India on stainless steel material, particularly of the special precipitation hardening type used for machining the components of the shielding and sealing plug assemblies. Using imported broaching tools, a Bombay firm successfully broached all the components. This firm has now taken up manufacture of the broaching tool also and these broaches are currently being "tool proved". Import of special broaching tools thus may be minimised in future.

- Heat treatment of the precipitation hardening stainless steel requires operation of furnaces within very narrow temperature limits, and use of thermocouples, recorders and controllers which are precisely calibrated to ensure reliability in heat treatment. The manufacturing ,programme has helped in developing such heat treatment procedures, ensuring that the components pass stringent quality control tests.

### *Special Quality Control Methods Evolved*

**GREAT care has to be exercised in the assembly and testing of the sealing and shielding plugs as they form part of the pressure boundary of the primary cooling system, and also because once installed they cannot be approached for manual operation. Therefore, besides establishing clean room conditions, each *shielding plug* assembly is subjected to a functional test in the assembly shop while each *sealing plug* assembly is subjected to a "hot test" under simulated conditions. The sealing plug assembly is also subjected to a pressure test to ensure that the plugs are leak-tight.**

**At each stage of their manufacture special quality control methods had to be devised. The Atomic Fuels Division and the Central Workshops of BARC, the Central Machine Tool Institute, Bangalore and manufacturing agencies at Satara and Hyderabad together developed these methods successfully.**



**Broaching of plug assemblies. Manufacture of broaching tools has now been taken up.**

- Nitriding is necessary for some components for imparting hardness, good wear resistance and anti-galling properties, as these assemblies have to operate reliably while immersed in water, which is a poor lubricant. While the nitriding process know-how fo certain grades of carbon steels is available in India, such process know-how was not available for nitriding o corrosion resistant stainless steel Indeed, the corrosion resisting property of stainless steel itself tends to inhibit proper nitriding. *The credit for a break-*

**Inspection set up for precision checking of a component.**

**"Hot test" of sealing plug assembly.**

*through in this technology goes to the Atomic Fuels Division of the Bhabha Atomic Research Centre (BARC). The Division also developed the required quality control methods for these nitrided components.* On the basis of this development, special furnaces have been imported for nitriding operations on a mass scale. *But for the development of this nitriding process, over seven thousand components for each reactor unit would have had to be sent abroad for nitriding.*

- "Electrolysing" is a special chrome plating process required as a finishing operation of one of the components of the sealing plug assembly. Although for Unit 2 of the Rajasthan Station and Unit 1 of the Madras Station, this component has been sent abroad for electrolysing operations (all the pre-and post-electrolysing operations being done indigenously), facilities are being set up at BARC, Trombay, for meeting future requirements.

- A special deposition technique whereby stellite can be satisfactorily deposited on stainless steel grade 410 has also been developed. Initially, the deposition techniques were developed at the Reactor Engineering Division of BARC; later the production components were "stellited" at Bharat Heavy Plate and Vessels, Visakhapatnam. The components were finish-machined by an Indian firm at Hyderabad. ●

# *Improved Designs For Plug Assemblies Being Evolved*

(*Continued from page 1, col. 2*)

required to close the end fitting openings against the high pressure, high temperature coolant inside the channel. The coolant is heavy water, an expensive commodity. As there are over 600 sealing plug assemblies in the reactor, it is essential that the sealing plug assemblies provide absolute leak tightness. Besides, like the shielding plugs, sealing plugs also must be capable of operation by the fuelling machines during on-power fuelling. The sealing plug assemblies are composed of components that are even more precise in their dimensional requirements.

While the manufacture, assembly and testing of the components was done here, the raw material and other special items like Inconel X springs, roll pins, retaining rings made of precipitation hardening stainless steel, etc. were imported.

The fabrication of these components requires special facilities, tools and skills which were developed and made available by both the private and public sector industries. The Atomic Fuels Division, the Reactor Engineering Division and the Central Workshops of the Bhabha Atomic Research Centre, the Central Machine Tool Institute, Bangalore, the Bharat Heavy Plate and Vessels, Visakhapatnam and some private engineering works at Bombay, Satara and Hyderabad were involved in the job.

This programme has helped in the identification of areas where manufacture of components is difficult. Operational experience has also indicated the desirability of introducing some new features, especially in the coolant channel sealing plug assemblies. Utilising the experience gained in this programme, designs for an improved model of the coolant channel sealing plug assembly are being evolved. Prototype manufacture of a modified design is on hand with a view to incorporating the same in the new reactor units. ●

# *DNA Repair and its Role in Cancer and Aging*

by **N. K. Notani**
and
**Marie F. George**
Biology and Agriculture Division
Bhabha Atomic Research Centre

THE deoxyribonucleic acid (DNA) carries the hereditary information in all cellular organisms. The central dogma of molecular genetics asserts that for expression this genetic information is first transcribed into RNA (ribonucleic acid) and then translated into proteins. DNA, RNA and proteins are linear polymer chains respectively of deoxyribonucleotides, ribonucleotides and amino acids. Genetic information is specified by the *sequence* of nucleotides and the genetic code is read three nucleotides at a time in a non-overlapping fashion. A triplet of nucleotides or bases specifies one amino acid. The one-gene one-enzyme hypothesis states that one (structural) gene codes for one polypeptide (protein). If there is a change in the DNA sequence by way of a deletion or addition or substitution of a nucleotide (pair) this is very likely to be manifest as a mutation. An example of this is the mutation affecting human haemoglobins such as in sickle cell anemia wherein a single base change results in altered haemoglobins which are functionally impaired.

DNA not only is to be expressed coordinately during the lifetime of an organism but also needs to be replicated. DNA in the cell is organized into one or more chromosomes. The chromosomes are giant molecules and in bacteria they consist almost entirely of DNA. To give an idea of how big these molecules are we compare the length of the bacterial cell with the DNA molecules that it contains. The length of the colon bacillus *Escherichia coli* is about 1-2 μm (1-millionth of a metre) whereas the length of its chromosome is more than 1100 μm. Thus, inside the cell, the chromosome must be condensed greatly so as to be accommodated within the dimensions of the cell.

Each normal human cell contains 23 pairs of chromosomes. If the DNA of these is placed end to end extended it will run into 3.9 metres. By virtue of its being the repository of genetic information, DNA must be replicated with a very high fidelity. The double-stranded, helical structure of DNA as proposed by Watson and Crick in 1953 suggested a plausible mechanism of DNA replication. A key feature of the Watson-Crick-structure of DNA is that the two chains of DNA are held together by *complementary* base pairing through (weak) hydrogen bonds *i.e.* if one strand has adenine at a place it will necessarily have thymine in the opposite strand. Similarly, guanine will pair with cytosine. It was imagined by Watson and Crick that during DNA replication, the two strands separate and each strand then sythesizes a complementary strand. This was subsequently borne out by the experiments of Meselson and Stahl. From the point of view of DNA repair, it should be noted that even if one strand of a duplex is destroyed, it can, in principle, be regenerated from the information contained in the complementary strand.

### *Prebiotic synthesis of nucleic acids and evolution of early repair systems*

THIS brings us to the main point of our article, that of DNA repair. It is considered probable that life on earth started about 4 billion $(4 \times 10^9)$ years ago. At that time ultraviolet radiation was probably more preponderant than all the non-electromagnetic sources, and could have been the dominant source of energy for prebiological synthesis. Oxygen and ozone were not present at that time which would have then let the ultraviolet (UV) light from the sun, reach the earth's surface unfiltered. Under these conditions, UV as an energy source may have helped produce not only some of the key compounds but also may have helped in polymerization of mononucleotides. Initially, there would be emphasis on 'protecting' primitive nucleic acids. Both single-stranded oligonucleotides and polynucleotides are highly susceptible to the action of ultraviolet light. An early mechanism that could redress the damage might have been the exposure to 240 n
(nanometre=one billionth of a metr
radiation. This radiation can 'split' t
main product of UV irradiation *vi*
pyrimidine dimers *in situ i.e.* witho
breaking the chain. This so-called sho
wavelength reversal would not opera
once the ozone layer was formed. Oth
repair mechanisms have evolved, mos
ly enzymatic, some of which speci
cally cope with UV-induced dama
and others which are more of a gener
nature and can tackle damage cause
in DNA by a variety of physical an
chemical agents.

A point should be made here regar

ing evolution. Biological evolution pr
ceeds by the occurrence of variabili
(mutations) in populations followed
the operation of natural selection whi
favours those organisms which are be
adapted to a milieu and which a
reproductively superior. The occurren
of mutations is a random process b
the frequency of mutations may be
function of the repair processes of
cell.

### *Model systems for repair DNA in E. Coli*

THE analysis of DNA repair h
been greatly facilitated by the is
lation of mutant strains of bacte
that are more *sensitive* than the norn

strain (wild-type in the jargon) to the inactivating actions of an agent. The first strain isolated was in *E. coli*—the so-called Bs-1 strain. This strain is highly sensitive to the action of UV. The most preponderant change that UV induces in DNA is the pyrimidine dimers between adjacent pyrimidine bases in the same DNA strand. If these dimers are not redressed or excised, the DNA replication is inhibited and the cell may die. The number of pyrimidine dimers formed in the genome of wild-type strain and in Bs-1 is the same. Therefore, it seemed conceivable that it was the removal of these dimers which was defective in strain Bs-1. Such data were provided by Setlow and Carrier. Subsequently, several other mutant strains have been isolated each of which has a single defective gene. Apparently, in the repair-deficient strains an enzyme is lacking or altered which then cannot catalyze the repair step that it normally does. At least four repair-systems have been discovered in *E. coli*.

1. *Photoreactivation:* Photoreactivating enzyme specifically binds to pyrimidine dimers induced in DNA both *in vivo* and *in vitro*. This complex can be energized by light having wavelength of about 300-550 nm. The dimers are split *in situ*. This *splitting* of dimers is to be contrasted with another repair mechanism which *excises* the lesion through the participation of a number of enzymes. Photoreactivating enzyme in *E. coli* is coded by a single gene designated *phr*. The number of molecules of photoreactivating enzyme in a cell ranges from only about 5-20. These could be sufficient for repairing damage caused by solar ultraviolet radiation.

2. *Excision repair :* None of the other enzymatic repair systems require light. Excision repair requires the participation of a number of genes and enzymes—in particular the enzymes involved in making breaks and removing the lesions in DNA synthesis (polymerases) and in sealing (ligases). There is a certain amount of non-specificity involved in this system. It is generally considered likely that what is recognized as damage is not the specific lesion but possibly a distortion in the DNA backbone. Such distortions could be produced by lesions induced by many agents.

3. *Post-replication repair:* Also discovered in *E. coli*, this system comes into play only following replication of the damaged DNA. An important element in this system is the filling of gaps, left opposite pyrimidine dimers during DNA synthesis, by transfer of intact segments from undamaged sister strand of the same polarity. This is a recombinational mechanism and has many similarities with genetic recombination that takes place in a normal cell.

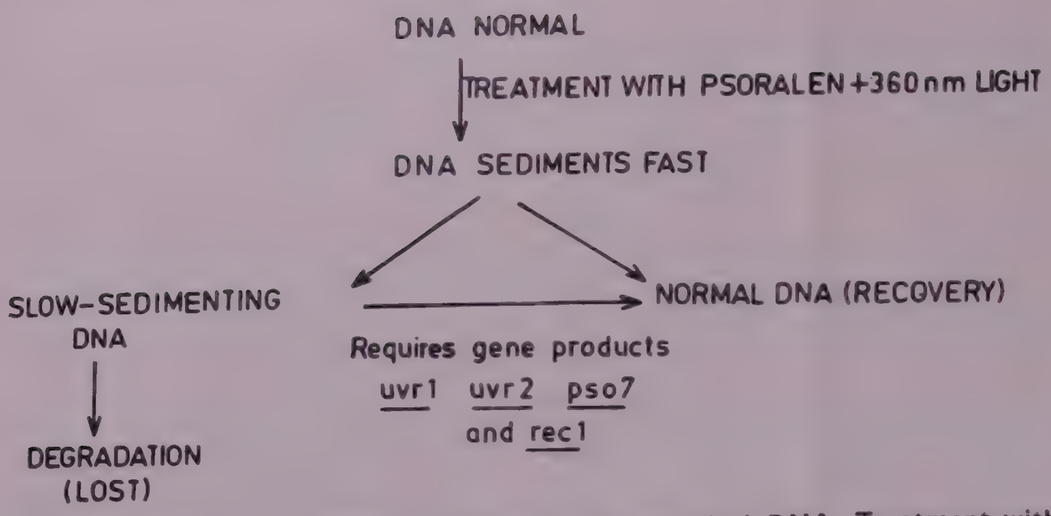
4. *SOS repair :* A recently-discovered repair system has been given the name of SOS repair because it seems to be *induced* in response to a sort of 'distress signal' in the wake of damage inflicted on the cell by an agent such as UV. Quite unlike the other repair systems, the enzymes of which are present in the *E. coli* cell throughout its life-cycle, this system is synthesized anew. Moreover, this repair system promotes not only repair of DNA to yield enhanced cell survival but is also mutation-prone. At least three genes have been discovered, one of which is common in the post-replication repair of DNA of *E. coli*.

## Repair of Crosslinked DNA

We have discussed at some length the repair systems that cope with UV-induced pyrimidine dimers. We now discuss a somewhat different mechanism and describe our own work in this context. It is described in the Vedas that vitiligo (leucoderma) can be treated with the application of a plant extract followed by exposure to sunlight. The active ingredient in the plant extract is a psoralen and, together with 360 nm light, is a current method of treatment for another skin disorder, namely, psoriasis. We became interested in the problem of repair of damage caused by psoralen + 360 nm light because this induces interstrand cross-links between two strands of DNA. Expectedly, such a cross-linked DNA will not be able to replicate since the strands cannot separate unless the cross-links are removed. Cells should have repair mechanisms that would cope with such damage. Indeed in *E. coli* it was demonstrated that there is such a mechanism. This mechanism is predominantly recombinational. However, when we studied sensitive strains in *Hæmophilus influenzæ*, we found that our recombination-deficient strain was not very sensitive. Therefore, the mechanism of repair of cross-linked DNA must be somewhat different. Our notion of the DNA events that occur in psoralen-treated cells and how the repair of cross-linked DNA might be occurring in *H. influenzæ* is shown on page 6. At least four genes participate in this repair. The overall events in DNA are as follows : Following treatment of cells, the DNA contained in these has sedimentation properties different from untreated DNA. It sediments fast but subsequent strand cutting and joining yields molecules which are like the normal ones. The biological recovery is correlated with this. Part of the DNA is degraded and is lost. In Fig. 2 we give the various steps by which cross-links are removed and DNA repaired. Our data suggest that the gaps filled by intact segments in *E. coli* be filled by another mechanism in our system. We think that gap-filling in our system occurs by the insertion of nucleotides. However, this may not be a very precise mechanism and therefore could be mutation-prone.

Mutation frequency, whether spontaneous or induced in bacteria is greatly influenced by their genetic make-up. A single gene mutation could drastically increase or decrease the overall mutation frequency. In multicellular organisms, it may be desirable to have mutation and recombination only in the germline to provide the variability required for evolutionary forces to work. In somatic tissue neither would be necessary. Indeed in the somatic tissue both the frequencies are greatly reduced.

(*Continued on page 6*)



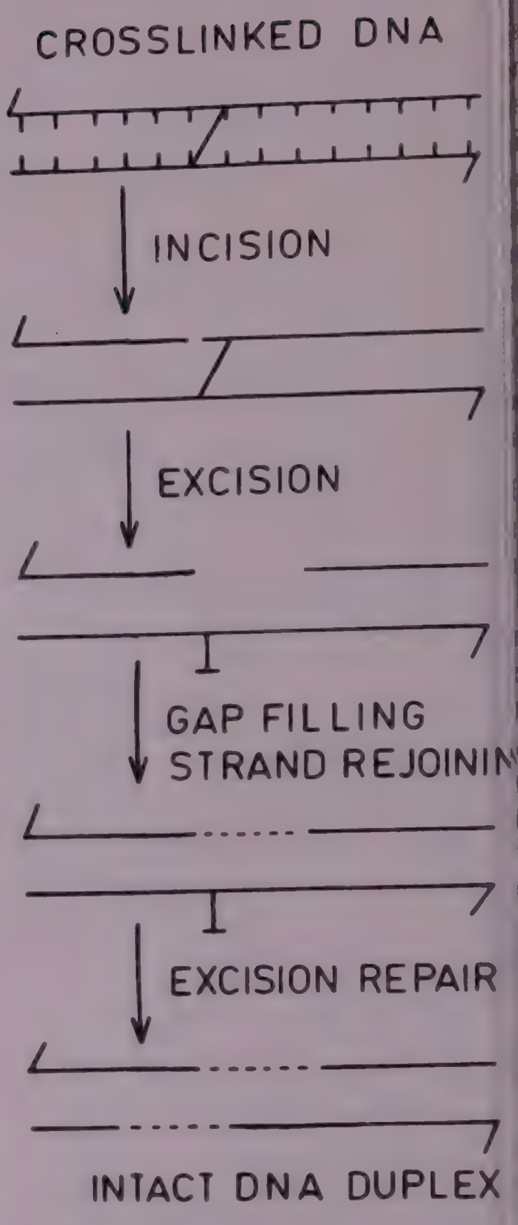


**Fig. 1 (top).** Molecular events in the repair of crosslinked DNA: Treatment with psoralen 360 nm light induces crosslinks in DNA which apparently cause it to sediment faster than the normal DNA. A part of this DNA returns to its normal sedimenting rate and part of it undergoes strand cutting and sediments slowly. Some of the slow-sedimenting DNA undergoes repair and then sediments normally. There is also some break-down of DNA and the products of degradation are lost.

**Fig. 2 (right).** One possible scheme for repair of crosslinked DNA as suggested by our results in *Haemophilus influenzae* : A damage-specific enzyme makes a nick next to the crosslink. Another enzyme then chews up the DNA leaving the half-excised crosslink attached to the complementary strand. Gap produced is filled not by a recombination mechanism but by insertion of nucleotides. The half-excised cross-link is next removed by a series of steps to yield an intact duplex.

(*Continued from page 5*)

## *DNA repair defects in genetic disorders and increase in malignancies*

DNA repair work with bacteria led to a search for similar systems in humans. The first breakthrough came when it was observed by Cleaver that cells from xeroderma pigmentosum (XP) patients were more sensitive to the actions of UV than those from normal humans. Xeroderma pigmentosum is a genetic disorder in which the patient is sensitive to sunlight and gets all types of skin cancers (see Fig. 3). It was observed that XP cells are defective in pyrimidine dimer excision and repair synthesis. It has been shown recently that XP cells are also deficient in photoreactivating enzyme. 'Variants' of XP are deficient in photoreactivating enzyme but not in repair synthesis. Some of these, however, have been found to be defective in post-replication repair. Thus, the total repair capacity (including the three repair systems) of XP cells is much lower than that of normal cells. These observations raised the interesting possibility that defect in DNA repair may be causally connected to occurrence of cancer in XP individuals. This would implicate pyrimidine dimers as the lesion for cancer as well, since it is already established that UV-induced pyrimidine dimers in DNA are lesions both for cell survival and mutation induction.

Direct evidence on this point has been provided recently by the work of R. Hart and R. B. Setlow. Working with a fish *Poecilia formosa*, they showed that when they took out cells from different organs, exposed the cells to UV and then injected these into isogenic recipients, these induced large granulomas in 10% of the fish and thyroid carcinomes in 100% of them. However, if the UV-irradiated cells were exposed to visible light for photoreactivation then lesions were reduced by a factor of 10. Since photoreactivating enzyme is specific for pyrimidine dimers, it may be concluded that pyrimidine dimers in DNA cause neoplastic transformation.

There is additional evidence which suggests that DNA is the target for the actions of physical and chemical agents and that alterations induced in DNA are prerequisite for neoplastic transformation. A very strong correlation has been observed by Bruce Ames and his co-workers between the known carcinogenic chemicals and their ability to induce mutations in the bacterium *Salmonella typhimurium*.

In fact, the correlation is so stro
that on the one hand it suppo
the idea of the mutation basis
cancer and on the other it may al
a simple and economical screening
environmental carcinogens. A go
correlation has also been obser
by Stich between stimulation of D
repair synthesis in human fibrobl
and carcinogenicity of chem
compounds.

There is additional evidence t
connects, although circumstantially
defect in DNA repair capacity
induction of a cancer. Ataxia tele
giectasia (AT) is a hereditary disor
A high incidence of malignancie
observed in AT patients. It had b
shown that cells from AT pati
are defective in the repair of dam
in DNA caused by gamma-rays.
other hereditary disorders should
mentioned that could have def
in their DNA repair systems. Blo

'ndrome is a genetic disorder chacterized by increased sensitivity to unlight, stunted growth and an creased incidence of leukaemia or ncer of the gastro-intestinal tract. An creased frequency of chromosomal errations is associated with this ndrome. Hand and German have bserved that Bloom's syndrome ermal fibroblasts in tissue culture ad a much slower rate of DNA ain growth, than the normal cells.

The other hereditary disorder is anconi's anaemia (FA). There is an ncreased incidence of leukaemia and high frequency of chromosomal berrations. In figure 4 are shown e photomicrographs of chromosomal bnormalities observed in the cells of A patient. However, the rate of NA chain growth is normal in ese cells. FA cells have been shown be defective in excision of thymine imers. A deficiency in the excision f X-ray products is also observed. FA ells also show a defect in the repair f cross-linked DNA by mitomycin or psoralen + 360 nm light. Thus, ere is a reasonable correlation between the increased incidence of malignancies in certain genetic disorders and the defects in their repair capacities. However, this may be a very simplified picture.

## *DNA repair capacity and aging*

THERE is no single cause for aging. Some correlation is beginning to appear between aging and the repair capacity of the cells but this does not establish repair capacity as the only cause or even a cause for aging.

A rare genetic disorder, progeria, is associated with premature aging and early death. It has been shown that the cells of progeriacs are

(*Continued on page 8*)

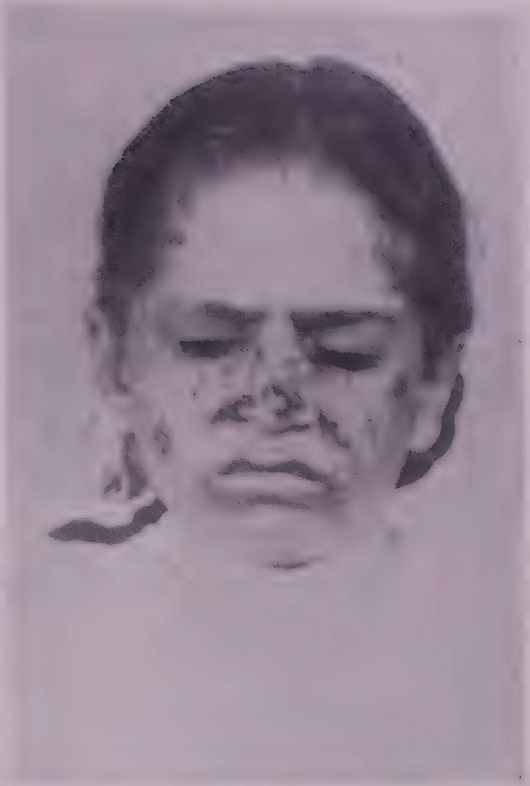
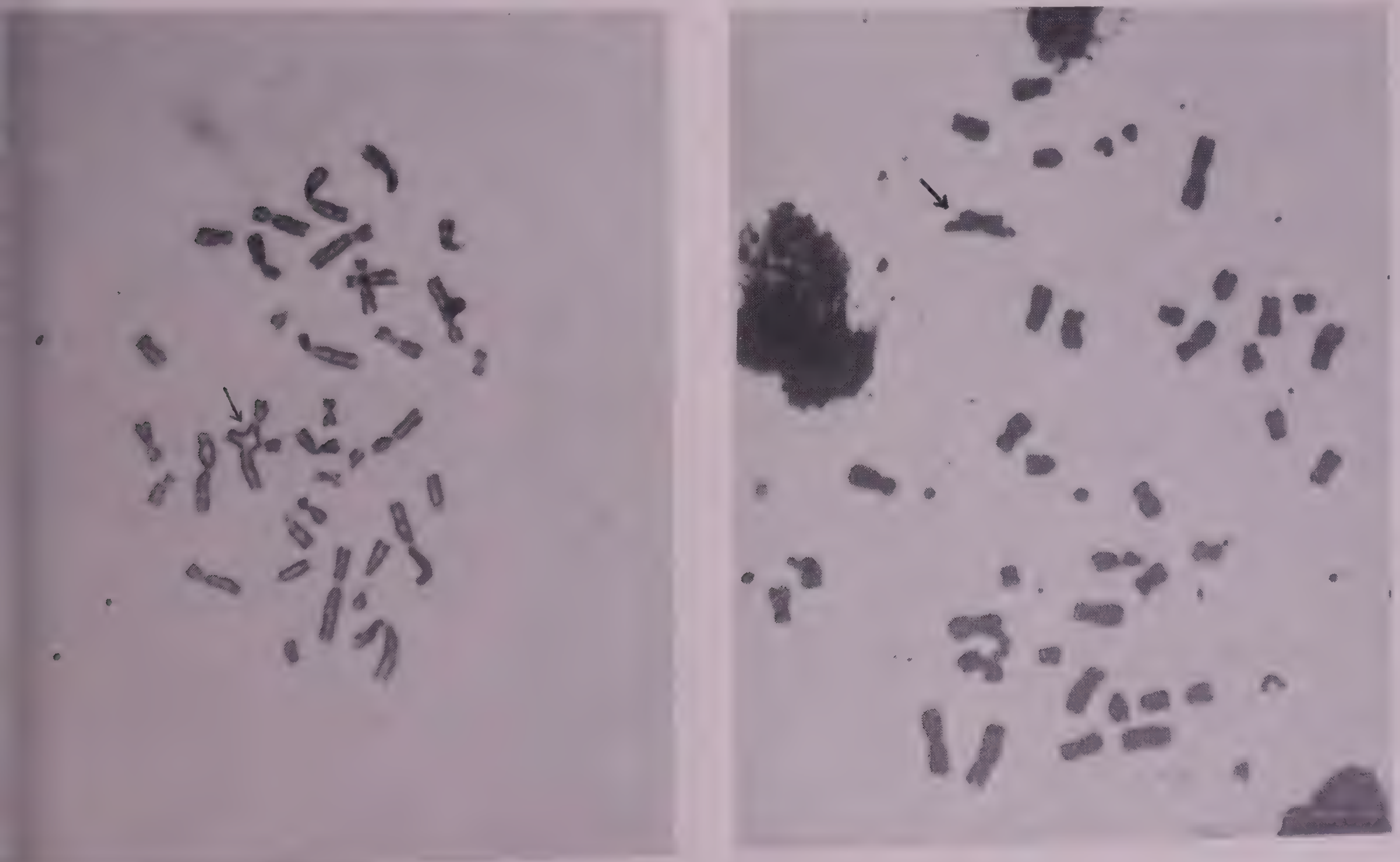


**Fig. 3 (top). Picture of a xeroderma pigmentosum (XP) patient. XP is a genetic disorder. The patients are sensitive to sunlight (UV) and develop all types of skin cancers. Skin fibroblasts from XP patients have been shown to be defective in repair of UV-damaged DNA.** *(Photograph kindly provided by Dr J. V. Undevia, Cancer Research Institute, Bombay.)*

**Fig. 4a & 4b (bottom). Fanconi's anemia (FA) is a group of hereditary diseases in man which is characterized by chromosomal instability, defective repair and increased frequency for the development of cancer. These two photomicrographs illustrate the breaks in chromosomes and other abnormalities in the cells of an FA patient** *(photomicrographs kindly provided by Miss Prochi Pavri, Genetics Unit, J. J. Hospital, Bombay.)*



# DNA Repair Studies Provide Insights on Cancer

(Continued from page 7)

defective in the repair of gamma-ray damage in DNA. This point is, however, under dispute and is contended to be an artifact of trypsin used in these experiments.

A gross correlation has been provided between the life-span of a species and the repair capacities of their cells (fibroblasts). R. Hart and R. B. Setlow have compared the repair capacities of the cells of man, elephant, cow, hamster, rat, shrew and mouse and observe that longer the life-span the greater the repair capacity. An inference from this is that unrepaired alterations in the structure of DNA could lead to aging.

Low repair capacity of human diploid lung fibroblasts has been recorded after fortieth doubling *in vitro*. In another study, fraction of repairing cells decreased in senescent cells. Holliday has shown that the fidelity and activity of DNA polymerase decreased with increasing passage of human fibroblasts and this could be a factor in aging. Total evidence in favour of cellular repair capacity as a major cause of aging is as yet circumstantial. It nevertheless suggests that additional research may turn up firmer links.

## Conclusions

MOTIVATION for doing research on repair of DNA came relatively late compared to the studies on other aspects of DNA metabolism. A reason for this could be that there were no pre-existing genetic parallels for DNA repair as there were, for example, for other chromosomal functions of replication, mutagenesis and genetic recombination. A major impetus for this research came from the radiobiological studies. These studies have revealed not only the presence of very sophisticated mechanisms in living organisms that can cope with a variety of damage induced by physical and chemical agents but have also led us to our understanding of the evolutionary aspects of prebiotic synthesis of nucleic acids and of damage rectification. The way in which repair mechanisms can regulate to provide an optimum rate of mutation for a species can also be visualized. Although studies on DNA repair are justified for their own sake, they have provided unexpected insights into the problem of cancer. Complexities of the cancer problem are well-known and cannot be oversimplified. Nevertheless, a number of lines of evidence, particularly from the studies of cells from patients with genetic disorders suggest that deficiency of repair capacity could lead to neoplastic transformation
human beings. Mutation-proneness a
the inducibility of some of th
repair systems is just coming to lig
Our complete understanding of th
may turn out to be momentous
the cancer problem as there is alrea
evidence that somatic mutation co
be the basis for a large number
environmental cancers. The ag
problem is also very complex a
the evidence as yet is rather circu
stantial in implicating deficiency
DNA repair systems in aging. It
however, apparent that DNA rep
studies have provided good leads
several directions.

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# *Iron Nuclei Boosted to 106 GeV at Berkeley*

IRON-56 nuclei completely stripped of orbital electrons have been accelerated to 106 GeV by the Bevalac accelerator at the Lawrence Berkeley Laboratory. Though the energy was high, the intensity was low—but there are plans to accelerate nuclei all the way up to uranium, after some modifications are made that will maintain better intensity.

The Bevalac—a combination of the SuperHilac linear accelerator and the Bevatron synchrotron—was linked as a single unit in 1974. Planned modifications are a new heavy element injector to be added to the SuperHilac, and increased bevatron ring evacuation so that beam particles will not combine with gas atoms in the vacuum. Funding for the modifications is expected this year, with completion due for 1978.

The SuperHilac alone has accelera
atoms as heavy as xenon-136, but
limited to the MeV range. Combir
with the synchrotron, it is hoped
ionize and accelerate atoms of virtua
any naturally occurring element throu
uranium. (*Nuclear News*, Nov. 76)

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VOL. 15. No. 6 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY FEBRUARY 1977

NUCLEAR INDIA

## Fuel Complex Begins Export of Ultra High Purity Indium

THE first consignment of ultra-high purity indium produced at the Special Materials Plant (SMP) of the Nuclear Fuel Complex (NFC), Hyderabad has been sent to West Germany. This is part of an order for 150 kgs, worth Rs 3.5 lakhs, placed with NFC by that country. This is also the first export of such a specialised product by the Complex.

The Special Materials Plant was set up at the Nuclear Fuel Complex primarily for producing ultra pure materials needed by the electronics industry. The purity of these materials is normally in the range of 99.999 per cent. Indium metal is one of such material in production at the plant which has the capacity to meet the country's entire requirement of the metal.

**Electro-refining of indium at the Nuclear Fuel Complex, Hyderabad.**

The ultra-high purity indium is used for p-doping in semi-conductor technology (particularly germanium transistors) and in the manufacture of flux-free low melting soft solders in the electronics industry. The process of production of this material from crude indium, developed initially at the Chemistry Division of the Bhabha Atomic Research Centre, was adopted at the Special Materials Plant for regular production on a large scale. This process involves multistage electro-refining of crude indium in an aqueous solution of indium sulphate. Electro-refining (shown in the picture) is done using soluble anodes of crude indium and cathodes of high purity indium. The cathode deposit so obtained is cast into ingots under vacuum, and zone-refined.

Besides indium, other ultra-high purity materials produced at the plant are selenium, tellurium, cadmium, bismuth, tin, lead, zinc, gallium, arsenic, gold, silver, boron tribromide, phosphorous oxychloride, manganese nitrate and sodium iodide. SMP also produces tantalum anodes for tantalum capacitors and micron-size zirconium powder for electron tubes, lamps, detonators.

So far the plant has produced finished products worth over Rs 90 lakhs, thus helping in the saving of foreign exchange of the same value as all its products were being imported before its establishment. ●

See special article : "Biological Nitrogen Fixation," on page 2.

## *Recovery of Byproducts at the UCIL*

THE Uranium Corporation of India Ltd., a public sector undertaking under the Department of Atomic Energy, operates an uranium mine and mill at Jaduguda in Bihar.

The uranium ore at Jaduguda contains small quantities of sulphide minerals of copper, nickel, and molybdenum. Besides these, another valuable mineral, magnetite, is also found in the ore. Realising the importance of these minerals, a feasibility study for their economic recovery was carried out which indicated that recovery of the minerals as by-products by flotation of ground ore pulp from the uranium ore processing plant was viable, without adversely affecting the recovery of uranium. A 40 MT/day pilot plant was subsequently installed adjacent to the uranium mill and extensive studies were carried out by the Ore Dressing Section of the Bhabha Atomic Research Centre and UCIL to collect data for designing a full scale plant.

*(Continued on page 7)*

# Biological Nitrogen Fixation

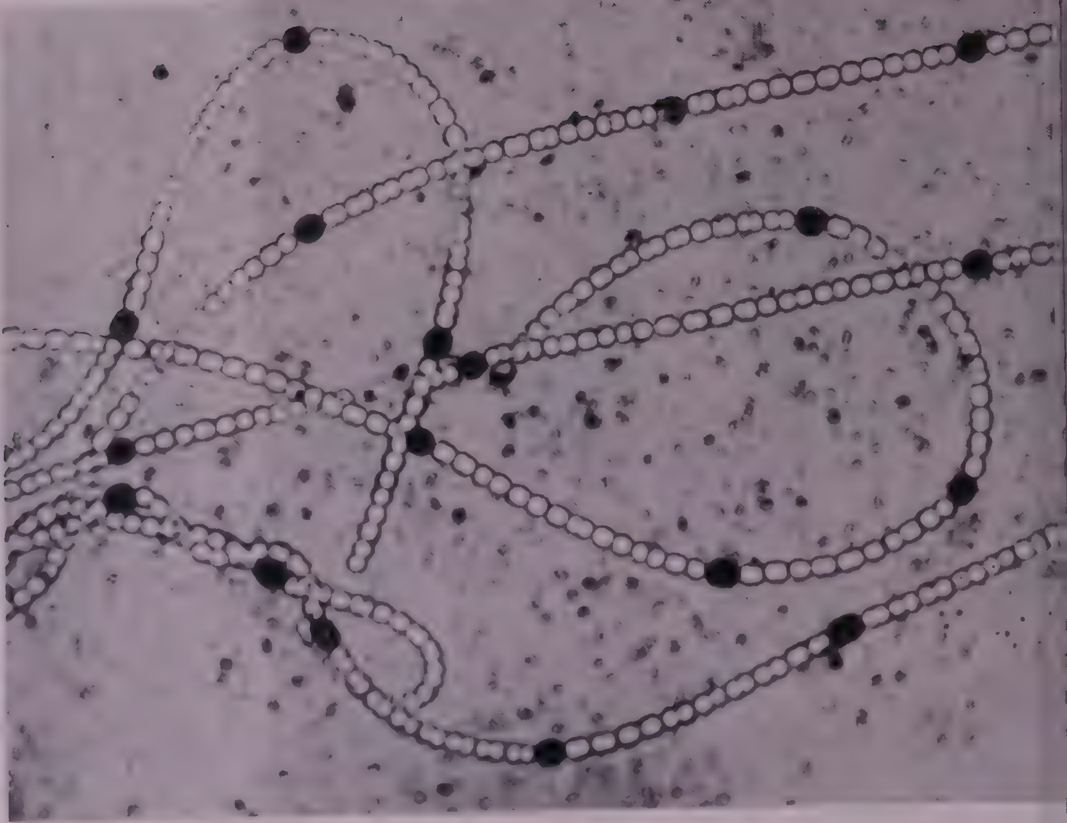


Fig. I. *Anabaena* L-31, a typical nitrogen-fixing cyanobacterium isolated from a pad
field near Bombay. Nearly 95 per cent of the cells photosynthetically assimilate C
and are called vegetative cells. The rest, referred to as heterocysts, are sites
nitrogen fixation. Nuclear emulsion is reduced by nitrogenase, turning the c
surfaces black.

NEARLY 90 per cent of the nitrogen turnover of the earth is met by biological nitrogen fixation. Most of this occurs outside the ambit of normal agricultural activity *i.e.* in forests, fallow land, lakes, rivers and the oceans. Man has not yet developed either the technology or agronomic practice needed to harness biological nitrogen fixation more efficiently for agricultural use.

Synthesis of nitrogenous fertilizers takes up the major share of the energy input in the manufacture of the three main fertilizer nutrients (N,P,K). Nitrogen demand for crop production, which was 40 million metric tonnes in 1974, is expected to quadruple by the year 2000. The need, therefore, for research on biological nitrogen fixation at the fundamental, strategic and applied levels cannot be overemphasized.

What is biological nitrogen fixation? In simple terms it is the process of reducing the "inert" dinitrogen ($N_2$ gas), which constitutes nearly four-fifths of the air we breathe, to the readily assimilable ammonia ($NH_3$), by living organisms. So far, such fixation is known to occur only in certain bacteria, either in association with plants (*e.g.* legumes) and animals (*e.g.* termites), or in the free-living mode—soil, aquatic and phyllosphere (found externally on plant leaves) bacteria.

Although the symbiotic rhizobia of legumes (pulse crops) form a major source of biological nitrogen fixation in crop production, the cyanobacteria, or blue-green algae, are perhaps the most important group of free-living microbes which augment the nitrogen status of agricultural habitats, especially in tropical countries. Nitrogen-fixing cyanobacteria are unique in that they simultaneously photo-assimilate carbon dioxide and nitrogen, and evolve oxygen. Many facets of the nitrogen-fixing process and related metabolism are beginning to be understood as a result of recent advances. Research and development work in the Biology and Agriculture Division of the Bhabha Atomic Research Centre includes studies on basic aspects of nitrogen fixation as well as evaluation for application in agriculture. The researches have enabled the understanding of the mechanisms by which the nitrogen-fixing enzyme is protected from inactivation by oxygen.

**by Dr. Joseph Thomas**
Biology and Agriculture Division
Bhabha Atomic Research Centre

The site providing the anaerobic mili
essential for fixation of $N_2$ to $NH_3$ h
been characterized and the pathway
ammonia assimilation leading to t
synthesis of amino acids has been elu
dated. The results also provide maj
insight into the factors that control t
formation of nitrogen-fixing cells a
the special features of cyanobacte
growing under saline stress. Data fr
field work hold promise for the develo
ment of a reliable agronomic practice
exploit cyanobacterial nitrogen fixati

## *Mechanisms in Nitrogen Fixation*

### Protection of nitrogenase from oxygen

The enzyme nitrogenase which ca
lyzes $N_2$ fixation (see box, P.5) is sever
inhibited by oxygen. However, enhan
cyanobacterial $N_2$ fixation accompan
increased rates of photosynthesis, w
concomitant $O_2$ evolution. The obvi
question therefore is: How is nit
genase protected from $O_2$ induced
activation? We evaluated the role
two distinct cell types found in acti
nitrogen-fixing cyanobacteria. A typ
example is *Anabaena* L-31 (Fig.

solated by us from a paddy field near Bombay. In *Anabaena*, nearly 95 per cent of the cells are of one type, referred to as vegetative cells. The rest are comparatively bigger, somewhat hyaline, with thick cell walls, and with a pinhead like body at each end (polar bodies). These cells are called heterocysts and appear when combined nitrogen ($KNO_3$, $NH_3$) is either absent or in low concentration in the growth medium. Do these cells, which are formed during the nitrogen-fixing mode of growth of cyanobacteria, evolve $O_2$? Are these the sites of $N_2$ fixation?

In cyanobacterial photosynthesis, solar energy, harvested by a set of pigments organized on specialised membranes (photosystem II or PS II), is channelised into reactions leading to the evolution of $O_2$. The pigments are c-phycocyanin, allophycocyanin, c-phycoerythrin and a form of chlorophyll *a* with an *in vivo* absorption maximum at 670 nm. Another set of pigments, *viz.* chlorophyll *a* 680 and carotenoids are constituents of photosystem I (PS I) which normally functions in tandem with PS II, but is capable of alternate modes of action leading to the formation of high energy molecules such as adenosine triphosphate (ATP) and molecules with high reducing potentials (reductants) such as reduced nicotinamide adenine dinucleotide phosphate (NADPH) and reduced ferredoxin.

Using a micro-spectrophotometer (which makes measurements on an area as small as 3/10,000 of a mm) we determined the absorption spectral characteristics of single vegetative cells and single heterocysts. Vegetative cells contain all the pigments of PS II and PS I, whereas heterocysts lack pigments of PS II (Fig. 2). Photosynthetic cells are known to show characteristic fluorescence emission spectra for PS I and PS II activities. A method, employing osmotic shock coupled with sonication, was developed to preferentially break vegetative cells, enabling the isolation of purified, metabolically active, heterocysts by density gradient centrifugation. Fluorescence emission pattern of such isolated heterocysts confirmed the absence of the PS II emission peak at 685-695 nm and the presence of the PS I peak at 715 nm (Fig. 3). Polarographic measurements on isolated heterocyst suspensions failed to indicate $O_2$ evolution. These results established that heterocysts of nitrogen-fixing cyanobacteria lack PS II and so would provide the anaerobic milieu essential for nitrogenase activity. Moreover, the requirement for ATP and reduced ferredoxin could be met by reactions channelized through PS I.

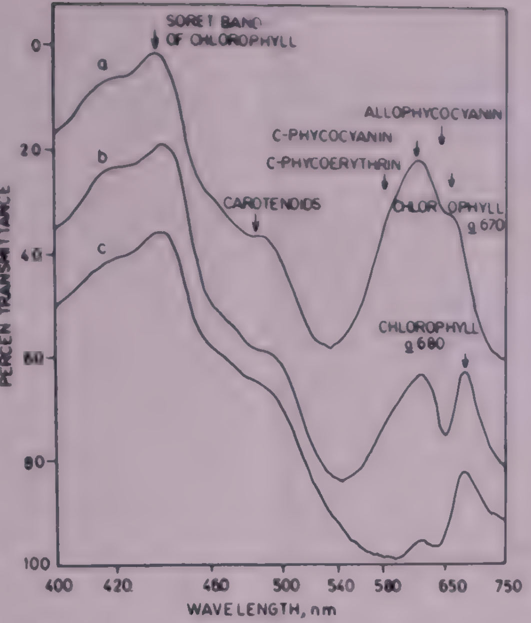


**Fig 2. Absorption spectra of single vegetative cells (a), single heterocysts (c) and single cells (b) in a transition stage from vegetative cell to heterocyst. Chlorophyll *a* 670, c-phycocyanin, allophycocyanin and c-phycoerythrin, all constituents of photosystem II (PS II) involved in the $O_2$ evolving process of photosynthesis, are absent in heterocysts.**

**Demonstration of nitrogen fixation in heterocysts**

*Reduction of nuclear emulsion*: When heterocysts and vegetative cells were coated with nuclear emulsion, only heterocysts caused blackening of the emulsion (Fig. 1). Since nitrogenase is a highly reducing enzyme it is an indication of the enzyme activity. The intensity of blackening, which was measured by the micro-spectrophotometer, served as an index of the enzyme activity.

*The acetylene reduction assay for nitrogenase activity:* Not only $N_2$, but a variety of other substances are reduced by nitrogenase (see P. 5). The discovery that nitrogenase reduced acetylene ($C_2H_2$) to ethylene ($C_2H_4$) revolutionised nitrogen fixation research. Small volumes of acetylene, introduced into a vial containing $N_2$-fixing bacteria, are reduced to ethylene which is released in the vial and can be easily measured by gas chromatography. This technique was applied for the first time in India using equipment developed in BARC, and the occurrence of nitrogenase activity was confirmed. Acetylene reduction is directly proportional to the number of heterocysts in the cyanobacterial filaments; isolated heterocysts have high specific activity for nitrogenase.

(*Continued on page 4*)

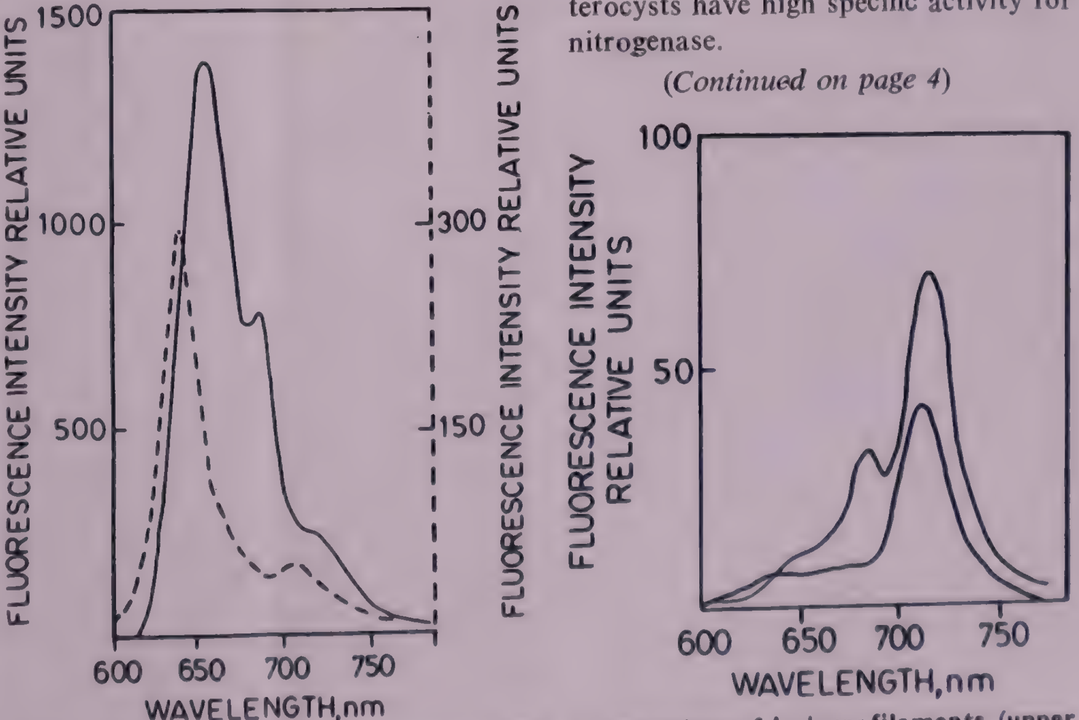


**Fig 3. Fluorescence emission peaks at 77°K of suspensions of *Anabaena* filaments (upper curves) and of isolated heterocysts (lower curves). Note that the emission peak in the 685-695 nm region, characteristic of PS II activity, is absent in heterocysts. The peak near 715 nm denotes PS I activity and is always present. The figure at left and the one at right depict emission spectra obtained by using 580 nm and 440 nm exciting light respectively.**

## *Outlook for the Future*

# *Global Nitrogen Fixation*

(*Continued from page 3*)

### *Development of a Radioactive Tracer Technique in Nitrogen Fixation Research*

UNTIL as recently as some months back tracer studies on nitrogen fixation could be carried out only with the stable isotope $^{15}N$. Long exposure periods (45 seconds or more) were required for the incorporation of detectable label, which would by then be distributed in many metabolites. Thus, the primary products of nitrogen fixation and the catalysing enzymes involved could not be characterized unambiguously. In collaboration with the Plant Reasearch Laboratory, East Lansing, U.S.A., methods have been perfected for generating $^{13}N$-labelled $N_2$ and $NH_3$ free of impurities. The $^{13}N$ is produced in the $^{13}C(p,n)\,^{13}N$ reaction using amorphous carbon targets and a minimum proton bombarding energy of 7 MeV available from an accelerator or cyclotron. Although $^{13}N$ has a half-life of only 10 min., we have developed procedures by which radioactive products of nitrogen fixation, after exposures as brief as 1 second to the isotope, can be extracted, purified and characterized by standard laboratory equipment.

Using $^{13}N$, the pathway of nitrogen metabolism was traced in the cyanobacterium *Anabaena cylindrica*. Dinitrogen is first reduced to ammonia, which is rapidly metabolised to form initially, glutamine and then glutamate, the key amino acid involved in further biosynthesis of various other amino acids. The enzymes responsible for these sequential reactions are nitrogenase, glutamine synthetase (GS) and glutamate synthase (glutamine amide: 2-oxoglutarate amidotransferase or GOGAT). The first two are coupled in heterocysts and the product glutamine is rapidly transported to the vegetative cells where GOGAT catalyses glutamate formation.

The operation of the GS/GOGAT pathway of ammonia assimilation is of crucial ecological significance. GS has very high affinity for ammonia, which is incorporated even at micromolar levels in amino acid biosynthesis. In contrast, glutamate dehydrogenase, the enzyme till recently implicated in ammonia assimilation, needs several fold higher concentration for efficient activity.

Small amounts of methionine sulphoximine inhibits GS activity preventing the formation of glutamine, but ammonia continues to form uninhibited and accumulates. These indicate the involvement of GS in the regulation of nitrogenase. The properties of GS may then be manipulated in a way that most of the newly formed ammonia is allowed to be excreted. One way being currently explored is to obtain mutants of cyanobacteria, with such altered properties, which could be used for biological fermentation of ammonia.

**Factors controlling the formation of nitrogen-fixing cells**

THE biochemical processes which control the formation of nitrogen fixing heterocysts are not clearly understood. In culture media containing combined nitrogen such as $NH_3$, $NO_3$ or certain amino acids, differentiation of heterocysts is inhibited, whereas in the absence of such nitrogen, differentiation is enhanced. How is this brought about? Is there a key inhibitor molecule which is synthesized from any of the above nitrogenous substances or is there in addition an inducer molecule which triggers the formation of heterocysts? We have been examining the extracellular products (substance secreted into the medium) of *Anabaena* growing under nitrogen fixing and non-nitrogen fixing conditions. Extracellular polypeptides isolated and characterized from both situations have a molecular weight near 5000 daltons, but have distinctly different amino acid composition. When added to a culture, the polypeptide from nitrogen-fixing condition, enhanced the formation of heerocysts, whereas the peptide from the non-nitrogen fixing condition inhibited their formation. Thus it appears that depending on the availability of nitrogenous substances in their habitat, the
bacteria synthesize either inducer
inhibitor molecules, the relative pr
portion of which regulates heterocy
differentiation.

**Sporulation in cyanobacteria**

Apart from heterocysts and vegetati
cells, cyanobacterial filaments posse
a third type of cell, the akinite or spor
These are usually formed when t
environment tends to be unfavourab
for growth. Spores can withstand a
verse conditions and start vegetati
growth once optimum conditions a
restored. Thus, these are importa
for the survival of cyanobacteria in t
soil. Often, cyanobacterial inocu
broadcast in soils perish because
the absence of spores in such culture
A crude factor isolated from *Anabae*
*torulosa* induces early and enhanc
sporulation. Present work is aimed
purifying and characterising this fact

**Nitrogen fixation under saline stress**

Crop plants in general fail to gr
in soils rendered saline due to bad fa
management, but many cyanobacte
can be adapted to thrive in such situ
tions. Such microorganisms may a
cumulate sodium—the main eleme
causing salinity—and after a period
growth the thin layer of top soil m
be removed, leaving soil with grea
reduced salinity. The possibility
augmenting the nitrogen status of t
soils is an added advantage if nitrog
fixing bacteria are employed in reclai
ing such farmland.

An understanding of the prima
mechanisms facilitating salt tolera
is essential for further developme
work. The kinetics of uptake of Na
labelled with $^{24}Na$ were examined
*A. torulosa*, isolated from a saline
bitat, and compared with that in
*abaena* L-31, a fresh-water cyanob
terium. Addition of DCMU (dichlo
phenyl-dimethyl urea), an inhibitor
photosynthesis, or growth in d
depressed the uptake of $^{24}Na$ in
fresh-water species whereas upt
increased in the saline species. T

# rch Effort

nd related data indicate that the fresh-water cyanobacterium expends energy lerived from photosynthesis to take in odium but it has apparently no mechanism to throw out the excess accumu-ated and thus cannot survive in a aline environment. In contrast, the aline form takes up sodium by a passive rocess, but utilizes energy to extrude xcess of the element. Such cyanobac-eria are thus able to cope with saline tress. Moreover sodium may be an ssential requirement for nitrogen fixation in cyanobacteria, for in *A. torulosa*, nitrogenase activity is greatly reduced in the absence of added sodium in the medium.

### Properties of Nitrogenase

Nitrogenase, the enzyme which catalyses the reduction of dinitrogen ($N_2$) from a valance state of zero to a valence state of minus three ($NH_3$) is a multi-subunit iron-sulphur and molybdenum-containing protein complex. There are two proteins, referred to as protein 1 and protein 2. Both proteins contain iron and sulfur, but protein 1 has in addition two atoms of molybdenum. Proteins of nitrogenase from the bacterium *Clostridium pasteurianum* are well characterized. Protein 1 has an overall molecular weight of 220,000 daltons and is composed of 4 subunits, two of which have a molecular weight near 54,500 each and the remaining two have a molecular weight of 50,700 each. Protein 2 comprises of two subunits each with a molecular weight of 27,500. Protein 1 has two Mo atoms, 24 Fe atoms and 24 sulphide groups, whereas protein 2 does not have Mo, but contains four Fe atoms and four sulphide groups.

Both proteins of nitrogenase are oxygen sensitive. The half-life in the presence of oxygen is a few minutes for protein 1 whereas it is only 20-45 seconds for protein 2.

In order to function, nitrogenase requires anaerobic milieu, an electron donor (ferredoxin), Mg and the biological energy currency, ATP. The requirement of ATP is particularly stringent, 20-30 moles of ATP being consumed for every mole of $N_2$ reduced to $NH_3$. Nitrogenase reduces not only $N_2$, but also numerous chemical analogues of nitrogen: small molecules containing a triple bond. Examples are acetylene, hydrogen cyanide, methyl isocyanide, hydrogen azide and nitrous oxide.

In laboratory experiments *Anabaena torulosa* grew well on soils with salinity values nearly three times the upper limit for most crop plants. After 5 weeks of growth, there was 50-70 per cent increase in soil N level. A significant portion of this was available as N excreted by the organism even after removal of the top layer of algal crust. There was 25-35 per cent decrease in salinity, suggesting that repeated cyanobacterial cultivation may entirely remove soil salinity.

#### Field work with nitrogen-fixing cyanobacteria

In field trials normally conducted in paddy soils, cyanobacteria are broadcast after transplantation of rice seedlings. Although the bacteria grow by fixing $N_2$, very little of this would become available to the rice plant immediately. The bacterial organic nitrogen needs to be degraded to yield ammonia or nitrate, compounds which are easily assimilated by plants. We, therefore took a different approach. Plots were flooded and inoculated with the bacteria three weeks before transplantation. During this period, daily rates of nitrogen fixation were assessed by the acetylene reduction technique. Fifteen to twenty days later the soil was ploughed over and kept in a semi-dry condition for 2 to 4 days to facilitate degradation of organic nitrogen. Rates of acetylene reduction (nitrogenase activity) were several fold higher in plots inoculated with cyanobacteria and there was substantial increase in the nitrogen content of the soil (Table 1, p. 6). These figures, would correspond to an increase from an initial value of 375-405 kg total N/hectare to 980-1520 kg total N/hectare. Paddy yield from these plots was comparable to that obtained when 80 kg N/hectare of urea was used (Table 2, p. 6).

## Current Agronomic Practices in India for Biological Nitrogen Fixation

INOCULATION of rhizobia for leguminous crops is the only significant agronomic practice currently in use and it is generally accepted to be efficacious. Several agricultural institutions and commercial units are supplying rhizobial packets to farmers. Azotobacters and, less commonly, cyanobacteria, the free-living nitrogen-fixers, are also being provided for use with cereals and other non-leguminuous crops. The efficiency of azotobacters, however, still remains to be established. Interestingly, an old practice common in some south-east Asian countries is being introduced in India. It involves the use of the water fern, *Azolla*, which harbours *Anabaena* as an endophyte in its leaf cavities. The fern grows profusely in shallow ponds and is used as nitrogenous green manure.

#### The Global Effort

IN recent years, great strides have been made in the use of genetic manipulation in nitrogen fixation research. Genes for $N_2$ fixation (*nif* genes) have been introduced from nitrogen-fixing bacteria to non-nitrogen-fixing bacteria and efforts are afoot to transfer and stabilize *nif* genes into higher plants. This task, although faced with the formidable constraints imposed by oxygen sensitivity and the complex regulation of nitrogenase *in vivo*, does seem achievable. For instance, man has already successfully transferred equally complex bacterial genes, although for different metabolic traits (*lac* and *gal* operons), to human and higher plant cells.

Genes are transferred by manipulated matings between bacteria (conjugation)

(*Continued on page 6*)

(*Continued from page 5*)

or through the agency of phages/viruses (transduction). The mobilization of *nif* genes on plasmids (extrachromosomal DNA) has opened up a promising avenue for gene transfer. These researches have also enabled chromosome mapping of $N_2$-fixing bacteria which should greatly help in the formulation of future research.

MOST of the advances in genetic work, however, have been made with species of *Klebsiella* and *Clostridium* genera which are of marginal value in nitrogen fixation in nature. Such studies will have to be extended to important $N_2$-fixers like rhizobia, cyanobacteria, and azotobacters. The recent discovery that rhizobia can be made to fix $N_2$ nonsymbiotically in synthetic media and the developments in tissue culture and somatic cell hybridisation techniques would facilitate major advances in this area.

Ammonia or a product of its metabolism represses $N_2$ fixation and, in nature, addition of comparatively low levels of fertilizer nitrogen inhibit nitrogen fixation. A beginning has been made recently in the isolation of mutants of *Klebsiella* and *Azotobacter* derepressed for ammonia inhibition of nitrogenase activity. Such strains could be further developed for field inoculation and for industrial fermentation of ammonia. This goal appears feasible when one considers certain current commercial processes which are based on genetically modified microbes. For example, some mutants of *Penicillium* produce about thousand fold greater concentrations of penicillin than that by wild type strains. For ammonia fermentation heterotrophic $N_2$-fixing bacteria may be adapted to utilize organic waste products. Processes for the microbial degradation of materials such as straw, waste wood products and garbage have to be developed. Photosynthetic cyanobacteria appear more attractive because organic carbon is not required for their growth.

Oxygen sensitivity of nitrogenase, as pointed out earlier, is a serious constraint in the expression of *nif* genes in higher plants. Isolation of oxygen insensitive mutants will be a revolutionary advance in nitrogen fixation research.

Genetic manipulation or genetic engineering work, however, has certain inherent dangers and has to be performed with great circumspection. For instance, in the absence of other limiting factors, mutants derepressed for ammonia inhibition conceivably could result in the accumulation of large excess of ammonia in soils with attendant pollution and may also trip the balance in the nitrogen cycle. Transfer of *nif* genes to a plant or animal pathogen may lead to exacerbated virulence.

## *Major Advances Made in Understanding Physiology and Biochemistry of $N_2$ Fixatio*

During the last decade major advances were also made in understandi the physiology and biochemistry nitrogen fixation. The protein co ponents of the nitrogenase compl have been well characterized and now have a better understanding of t basic process of $N_2$ reduction. Howeve many facets remain to be elucidate Application of physical tools li X-ray diffraction, ESR and Mössbau spectroscopy is being intensified study structural details and aspects enzyme catalysis. Although there sizeable information on the involv ment of glutamine synthetase a adenosine triphosphate/adenosine di hosphate (ATP/ADP) ratios on t

(*Continued on page 8*)

**Table 1. Nitrogen Fixation by Cyanobacteria in Paddy Field**[1]

| *Treatment* | *Initial Soil N (mg total N/kg soil*[2]*)* | *Soil N after 21 days (mg total N/kg soil*[2]*)* | *Increase in soil after 21 day (mg total N/kg soil)* |
|---|---|---|---|
| Control (Flooding for 3 weeks +K, +P) ... | 175 (389)[3] | 532 (1183) | 357 (794) |
| Control + *Anabaena torulosa* ... ... | 168 (374) | 516 (1148) | 348 (774) |
| Control + *Nostoc—4* ... ... ... | 182 (405) | 683 (1519) | 501 (1114) |
| Control + *A. torulosa* + *Nostoc—4* ... ... | 175 (389) | 559 (1244) | 384 (855) |

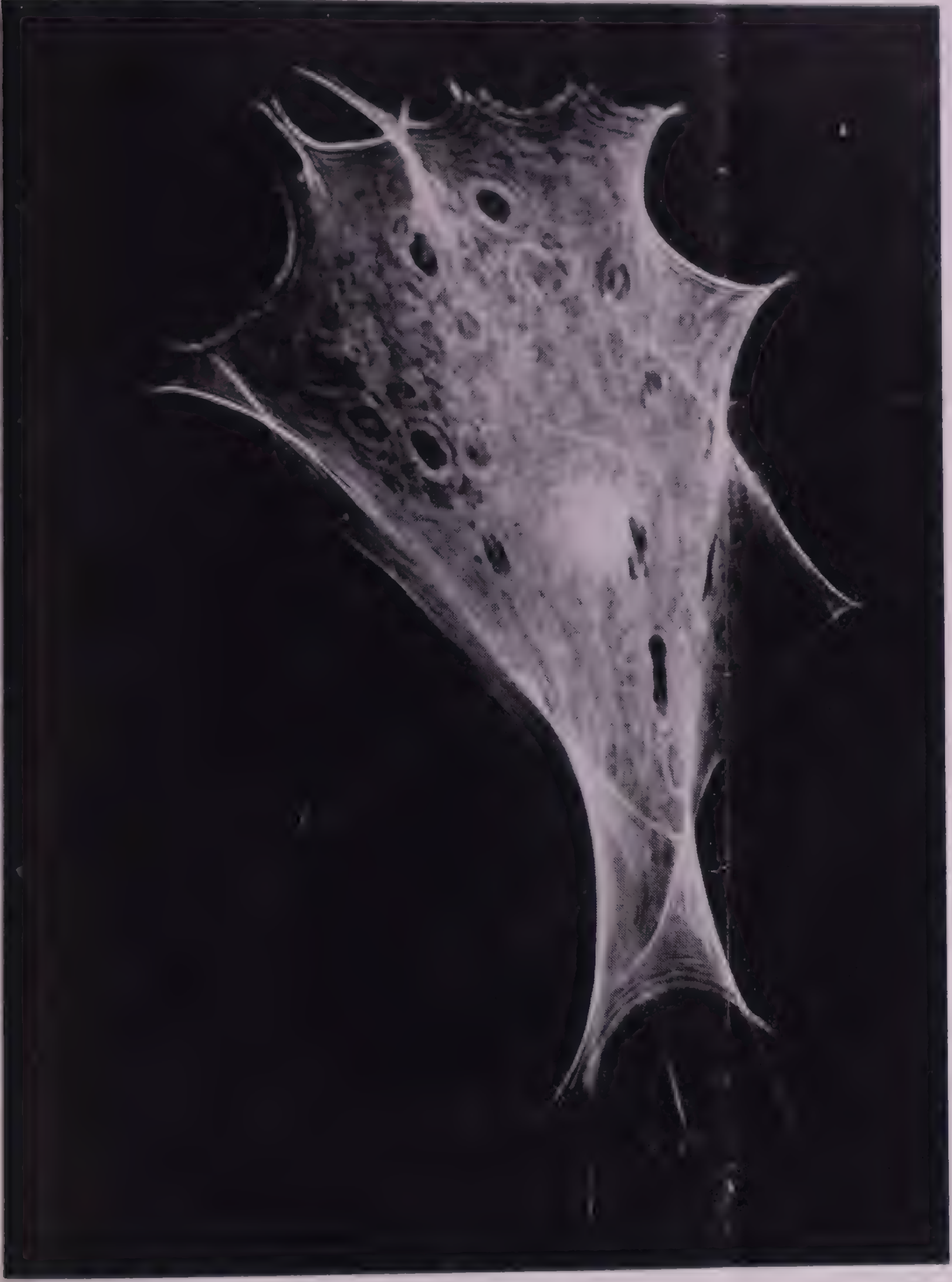
1. Trials were conducted on 20 sq. metre plots.
2. Each value is the mean of ten measurements.
3. Values in parenthesis are extrapolated to kg N/hectare. 10 per cent of "total N" is considere to be available to plants.

**Table 2. Effect of Cyanobacterial Inoculation on Paddy Field**[1]

| *Treatment* | *No. of tillers* | *Straw yield (kg/plot*[2]*)* | *Grain yield (kg/plot*[2]*)* |
|---|---|---|---|
| Control (+P, +K) ... ... ... ... | 455 | 12.0 (6433)[3] | 4.0 (2144) |
| Control + urea ... ... ... ... | 510 | 19.2 (10340) | 4.9 (2623) |
| Control + preflooding for 3 weeks ... | 440 | 14.4 (7734) | 4.1 (2182) |
| Control + preflooding + *Anabaena torulosa* ... ... ... ... ... | 426 | 13.1 (7030) | 4.3 (2294) |
| Control + preflooding + *Nostoc—4* ... | 478 | 19.0 (10298) | 5.9 (3174) |
| Control + preflooding + *A. torulosa* + *Nostoc—4* ... ... ... ... ... | 384 | 15.8 (8516) | 4.9 (2644) |

1. Rice variety D6-22 was used.
2. Plot size 20 sq. metres (210 sq. ft.).
3. Values in parenthesis are extrapolated to kg/hectare.

# *Pattern of Catastrophes*



**A field of modern mathematics known as 'catastrophe theory' can be applied to the study of wave motion by helping to explain and classify patterns such as the one seen in the picture, produced by refraction of a laser beam passing through an irregular glass plate. Refracted waves moving in various directions give rise to foci known as caustics, which form the sort of image seen here. Another more common example is a rainbow. Caustics can be considered to be 'catastrophes' within the terms of the theory and as such can be described mathematically. This photograph was taken at Bristol University by George Keene, the Physics Department photographer, in the course of work by Dr. M. V. Berry. (*Courtesy: "Spectrum"*)**

# Recovery of By-products at UCIL

(*Continued from page 1*)

The construction of the by-products recovery plant was started in March 1972. The design, development and fabrication of the plant equipment were done indigenously. Commissioning trials were started in August 1974, and after some modifications, regular production commenced in May 1975. (see *Nuclear India* July 1975 and February 1976.)

While sulphide minerals of copper, nickel and molybdenum are recovered by flotation process, part of the tailings are treated for recovery of magnetite after recovery of uranium at the Jaduguda mill. The magnetite produced is supplied to coal washeries for use in heavy media separation. A larger plant for recovery of all available magnetite in the ore is now being planned after establishing the economics of the process and market for this by-product.

### Economic Separation

The recovery of by-products from the ore, the primary content of which is uranium, has led to the development of indigenous technology for complete utilisation of ore minerals. The notable feature is recovery of molybdenum. UCIL is the only indigenous source of this mineral which is used for manufacturing ferro-molybdenum, now being imported. Indigenous production of molybdenite at UCIL has encouraged creation of roasting facilities for manufacture of ferro-molybdenum at various places. The production of copper concentrate is also a contribution towards saving of foreign exchange as a part of the country's requirements of the metal is still met by imports.

Economic separation of nickel from the copper-nickel concentrate which becomes available in the process has not been established so far as the quantity involved is small. Development work is now being done on separation of nickel from these concentrates, both at BARC and at UCIL.

— **R. K. Sahgal**

# Research on Increased $N_2$ Input

(*Continued from page 6*)

physiological regulation of nitrogenase synthesis and activity, still more is certainly warranted for a proper understanding of this complex aspect. For every mole of N reduced, 20-30 moles of ATP are consumed. But the role of this highly energy expensive aspect in nitrogen fixation is only beginning to be clarified.

Inorganic chemists have synthesized stable dinitrogen complexes including those of Mo and Fe, but efficient reduction of $N_2$ to ammonia using these complexes remains to be achieved. Research aimed at simulating the biological catalysis is being intensified because of the potential for discovery of a more economic commercial process for chemically reducing $N_2$.

### $N_2$ Fixing Bacteria

THIS brief overview of the current research trends mainly deals with those goals which would provide beneficial application in the long run. There are parallel short term goals which are relatively easily accomplished. Screening our soils for better nitrogen-fixing bacteria is one of them. Recent techniques of culturing nitrogen-fixing rhizobia in the free-living mode and in association with plant host cell tissue cultures will greatly facilitate primary screening of efficient nitrogen-fixers for leguminous crops. Agronomic practices have to be developed further for the application of cyanobacteria and azotobacters. The soil ecology and stress physiology of these microorganisms need to be studied.

The list of plant bacterial associations is steadily expanding. Nitrogen-fixing bacteria have been reported from roots of forage grasses (*Spirillum*) and from the rhizospheres (zone of soil near the root) of paddy and other crop plants. More such associations remain to be discovered. The root zone ecology (soil conditions and plant characteristics) which favour such associations has to be understood. Nitrogen-fixing bacteria have been isolated from leaf surfaces. The nitrogen-fixing potential of these phyllosphere microbes will have to be assessed. Spraying such bacterial strains on crop plants may contribute to fixation of nitrogen on the leaf surface itself.

In legume nitrogen fixation the rate is often limited not by the microbial nitrogen fixation machinery but by the availability of photosynthates translocated from leaves to the nodules. There is thus the need to isolate legume cultivars with better photosynthate availability.

While research is focussed on increasing nitrogen inputs by biological fixation, efforts also have to be made to improve the efficiency of utilization of nitrogenous fertilizers. Only 50 per cent of applied fertilizer is taken up by wheat, and only 30-40 per cent by paddy. A 50 per cent improvement in the efficiency of nitrogen fertilizer use would mean an annual world saving of nearly thirty billion rupees. In this context encouraging results were reported from recent research sponsored
by the Khadi and Village Indust
Board where neem cake applied al
with urea effected a significant red
tion in the loss of fertilizer nitrog
Bacteria which convert organic nitro
to nitrite and nitrate which are ea
lost by leaching, are apparently
hibited by neem cake.

It is evident from the foregoing
overall progress in research on biolog
nitrogen fixation will depend on
efforts of not only biologists, p
breeders and agronomists but
chemists and physicists. Interdisc
nary collaboration is a vital nee
this crucial endeavour to harness
logical nitrogen fixation for enhan
crop productivity.

## NUCLEAR INDIA

**is a monthly publication of the Department of Atomic Energy, published around the 20th of each month. To ensure prompt attention, all communication should be addressed to the Editor, NUCLEAR INDIA, Department of Atomic Energy, Chhatrapati Shivaji Maharaj Marg, Bombay-400 039. While intimating change of address, the code and number given on the wrapper should be mentioned. Bombay recipients may contact 25 04 77 for prompt action.**

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## *NAARRI*

NAARRI, the National Associatio
for Application of Radioisotopes an
Radiation in Industry completes on
year this month : it was established o
February 27, 1976 by the participants t
the National Symposium on Industria
Radiography held at the Bharat Heav
Electricals, Tiruchirapalli at the time.

The major aim of NAARRI is
(1) to provide a national forum fo
discussion, and dissemination of infor-
mation on application of radioisotope
and radiation in industry, (2) to offe
expertise and advice to industry on the
availability of equipment and accessorie
for the safe application of radioisotope
and radiation and (3) to help in th
formation of ancillary units for produc-
tion of equipment for the exploitatio
of nuclear techniques by industry.

In India over 1,000 industrial an
research organisations use radioisotope
and radiation in one way or the other
Nearly 3,000 members in the country ar
directly or indirectly concerned wit
furthering the application of isotope
and radiation in industry, and in R &
work.

Dr. V. K. Iya, Director, Isotop
Group, Bhabha Atomic Research Centr
is the President of the Association.

Further information on the NAARR
may be obtained from the Secretary a
the :

Isotope Group
Bhabha Atomic Research Centr
Trombay, Bombay 400 085.

Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India,
Chhatrapati Shivaji Maharaj Marg, Bombay 400 039, and printed by him at G. Claridge & Co. Ltd., Bombay 400 001.

Registered No. R. N. 9002

NUCLEAR INDIA

VOL. 15. No. 7 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY MARCH 1977

# *Power Reactor Core Component Made for the First Time in India*

THE garter spring, a small but very important power reactor component, has been made in India for the first time by the Atomic Fuels Division of the Bhabha Atomic Research Centre (BARC), and the Nuclear Fuel Complex, Hyderabad.

The garter spring, made of zirconium-niobium-copper alloy, is located in the core of the Pressurised Heavy Water Reactor (PHWR), the type of reactor at the Rajasthan and Madras Stations and planned at Narora. The pressure tubes carrying fuel bundles and hot, pressurised coolant (heavy water) are located inside the calandria tubes, being separated from them by an annular space. Each pressure tube is supported by end-fitting bearings in the end-shields and by two garter springs located in the inter-tube annulus. The springs are situated about 60 cms on either side of the reactor centre line and on each of the 306 pressure tubes. A girdle wire passing through the spring holds it around the pressure tube.

Each 200 MW(e) reactor needs 612 garter springs. For the two reactors at the Rajasthan Station the springs were imported but for the reactors at Madras it was decided to make them in the country. The Atomic Fuels Division of BARC and the Nuclear Fuel Complex together took up the development work on this critical component and completed it successfully in a short span of time; the

(*Continued on page 8*)

**Garter springs made at the Nuclear Fuel Complex, Hyderabad**

# Complex Hot Cell Cranes Made at Trombay

IN a nuclear laboratory, a large number of operations involving highly radioactive substances are carried out by remote control within heavily shielded enclosures known as "hot" cells. The very delicate manoeuvres required for handling small quantities of radioactive materials from a distance are carried out with the aid of Master Slave Manipulators, essentially mechanical hands capable of slow, precise movements of the most intricate nature.

The transport of radioactive materials into the hot cell is also an equally delicate operation requiring the same degree of sophistication. Normally, such materials are moved into the cell in shielded (lead) containers. These containers, being heavy, require a device to handle them inside the cell. This job of lifting heavy loads within the hot cell is done by a crane built into the cell but controlled from outside.

**The Search for Uranium—page 4**

### Special Features

The Central Workshops of the Bhabha Atomic Research Centre has been designing and fabricating small capacity cranes to meet the ordinary needs of the Centre for some time. But the hot cell cranes demand special features requiring some sophistication in technology; they have therefore been imported all these years. In recent months, however, the Workshops have embarked on a project to make these cranes within the country and also to interest industry to take up its manufacture on a regular basis.

The cranes which the Workshops have taken up are needed by the fuel

(*Continued on page 3*)

## Symposium on Operating Experience of N-Reactors

A THREE-DAY symposium on "Operating Experience of Nuclear Reactors and Power Plants" was inaugurated by Dr. H. N. Sethna, Chairman, Atomic Energy Commission, in the Bhabha Atomic Research Centre (BARC), Trombay, on February 7. The symposium was attended by members of several Electricity Boards, public and private sector companies, and the engineers and scientists of the BARC, the Power Projects Engineering Division, the Atomic Power Authority and other units of the Department of Atomic Energy.

The primary objective of the symposium was to pool together operational experience of nuclear and conventional power stations with a view to improving plant performance, economy and safety.

The programme covered 12 invited talks and 80 contributed papers on plant operating experience.

In his welcome address, Dr. R. Ramanna, Director, Bhabha Atomic Research Centre, traced the history of development of nuclear plant operations in the BARC and described the strides taken by the country in building up competence in design, construction and operation of nuclear reactors. He stressed the importance of self-reliance for scientific progress and explained how because of this policy BARC had become self-reliant in formulating its own operating practices such as reactor core fuel loading, heavy water management, chemical control measure, maintenance and safety evaluation. As an example of self-reliance, he cited the 100 MW R-5 research reactor being built at Trombay. When completed, R-5 will be one among the powerful and versatile research reactors in the world, providing a variety of experimental facilities and producing radioisotopes in quantities. Everything about this reactor is Indian—nuclear and conventional design, construction, fabrication and management—including commissioning and regular operation.

In his inaugural address, Dr. H. N. Sethna underlined the need for improv-

(*Continued on page 3*)

# Trombay Designs High C

The crab is seen being lifted from outside for testing.

**Some Special Features**

Unlike the conventional cranes, the hot cell cranes have specially designed components for meeting their complex performance requirements. Important among these are the following:

- The "crab" is removable by remote control. This is done by locating the longitudina drive motor (LDM) in the crab pocket with the sliding pinion on the longitudinal drive shaft In conventional cranes the LDM is mounted on the end-carriage. The crab pocket enclosure has also to be purged of air with 5psi air pressure, with air line running along the electri cable.
- To bring the crab in line with the roof opening, the friction disc type solenoid operate clutch detaches the drive to enable manual operation. Remote operated tools control movement of crab in X, Y and Z directions. This operation of detaching the clutch results i decoupling. No brakes are therefore needed.
- Most of the components of the crane—the drive, rope, clutch, rollers, cable, take-up et are fabricated in stainless steel. The cable is insulated with special silicon rubber.

# y Cranes

(*Continued from page 1, col. 3*)

reprocessing and the waste immobilisation units at Tarapur in particular. Both these units handle very high radioactivity material. In the hot cells of the WIP units, the crane has to operate in low head room—of the order of 300 mm or even less; its speeds have to be very low due to the intricacy of the operations; the materail used in it must withstand high radioactivity and, often, chemical acid fumes. The area covered by it also has to be maximum *i.e.* the hook reach has to be as close to the wall as possible. And, most important, as the crane cannot be approached due to the radioactive environment, it has to be absolutely reliable in performance and durability.

As a first step, the Central Workshops took up the work of designing and manufacturing such cranes for the Waste Immobilisation Plant at Tarapur. While starting with the design work, it also approached the conventional overhead crane manufacturers in the country to interest them in the job. The response was very poor. However, one of them agreed to take up the work as a development project.

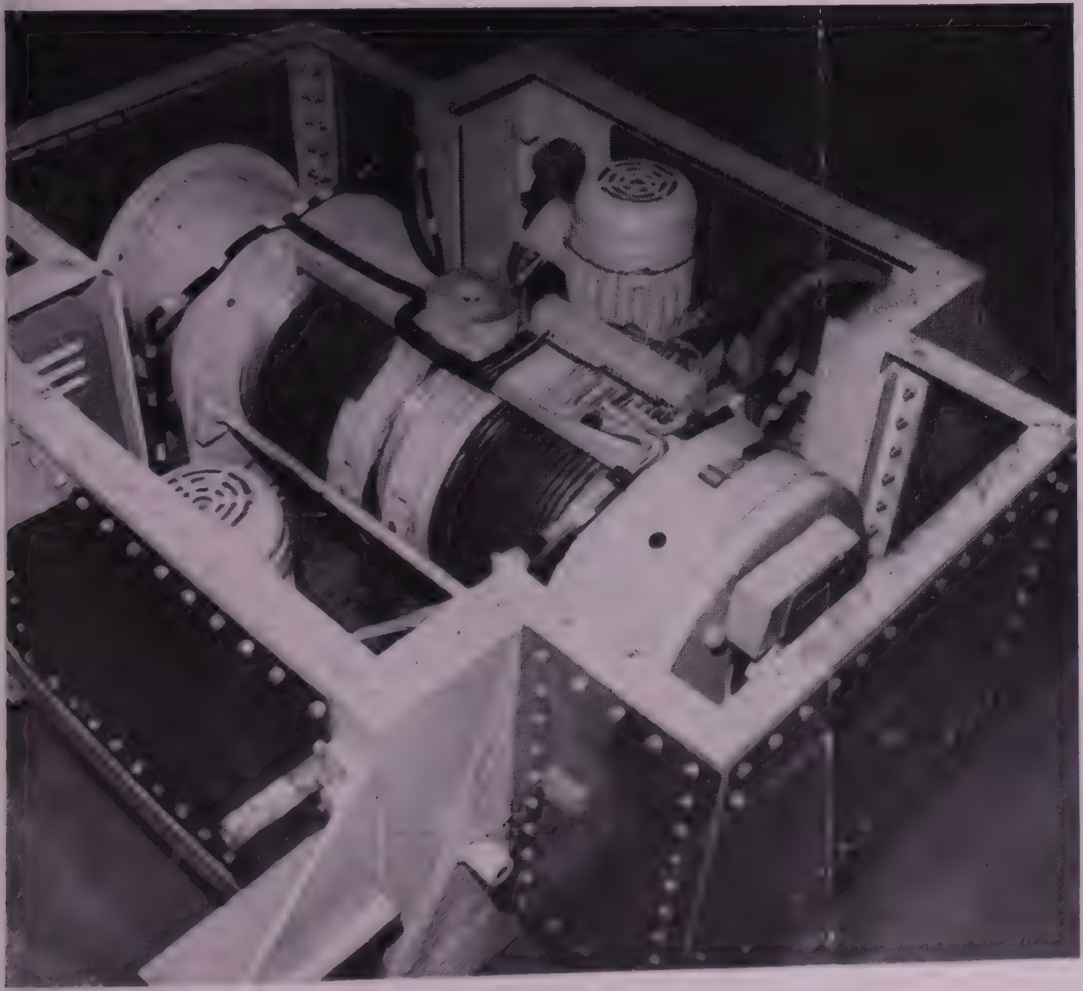
### High Capacity Cranes

The present requirement is of cranes of 1 tonne capacity. But the Workshops has decided to go in for units of 2 tonne capacity as a survey of future requirements in the country shows that the demand will be high for the higher capacity unit.

A prototype in carbon steel was made of the crab and other important components and the crane was assembled and tested jointly by the Workshops, the Waste Immobilisation Plant and the engineering firm involved. After ensuring that all the parameters and the rigid specifications were met, the crab and the other parts were remade in stainless steel, reassembled and tested by the Workshops and other users

(*Continued on page 8*)

**A view of the compact crab showing hoist unit and motors for longitudinal and cross motion.**



# Trombay Symposium

(*Continued from page 2*)

ing the operating efficiency of power plants in the context of the overall national economy and limited resources. Even a small increase in efficiency would mean several crores of rupees to the economy, both direct and indirect, he added. The importance of detailed written operating and maintenance procedures, and their documentation for easy implementation, review of unusual operational occurrences for improving plant operation, careful planning and advance action for procurement of spares for critical items, and the training aspect of operating staff, were also emphasized by him.

In the matter of maintenance, he advocated the need for indigenisation, standardisation and timely availability of the spares, and mentioned that the Department was prepared to assist the industry in this effort. Though, ever since its inception, the nuclear power industry has had the benefit of rigorous standards and codes, particularly from the safety angle, the conventional power industry has not had such benefit in the country. The Department has been collaborating with the International Atomic Energy Agency in the matter of preparation of the code of practice for nuclear power plant operation, and the Department would be happy to share its experience and expertise with the power industry for enlarging the scope of the code to cover the conventional power plants.

In his introductory remarks, the Chairman of the Symposium Committee, Dr. A. K. Ganguly, Director, Chemical Group of BARC highlighted the need for promoting exchange of information, views and ideas on the operating experience of nuclear reactors and power plants. The Department of Atomic Energy has accumulated several years of operating experience in nuclear power plants and has been interacting with different Electricity Boards and Regional Power Grids in the matter of power generation, he added.

The Secretary of the Symposium Committee was Shri S. M. Sundaram, Head, Reactor Operations and Maintenance Group of BARC. ●

# The Role of the Atomic Minerals Division

by **Dr. G. R. Udas**

Director, Atomic Minerals Division
Department of Atomic Energy

**The Atomic Minerals Division (AMD) of the Department of Atomic Energy h its beginnings in 1949 as the Rare Minerals Survey Unit under the then Minist of Natural Resources and Scientific Research. It started with a strength of just fo scientists in 1949, which rose to 44 in 1950 and is today 530, located all over t country.**

**Mining and drilling camp at Udaipur in Rajasthan. At right hand corner is shaft No. of the Umra Mines.**

## The Search for Uranium

THE search for uranium began almost three decades back in the forests of Bihar and Rajasthan. Our equipment consisted of a dozen Geiger Müller counters which were utilised mostly in Bihar. In Rajasthan, exploration work was confined to only beryl survey because GM counters were not available. In Bihar, with GM counters, we were lucky to strike the first radioactive occurrence of significance at Jaduguda in 1951. In those days very little was known about the grades of ore, minimum reserves required for making the deposit economically viable, the chemical, hydro-metallurgical and engineering-parameters for profitable recovery of uranium from ores or, more importantly, the factors to be considered for making investment decisions. Practically no information was available from international sources until the first international conference on peaceful uses of atomic energy in Geneva in 1955.

Learning from experience, and from occasional scientific meets, the uranium exploration programme in the country made steady progress; in 1956, the Jaduguda deposit, with a reserve of 40 tonnes under the 'indicated' category, and another 1000 tonnes under the 'possible' category, was opened by adits.* It was only then observed that the ore samples from deeper levels were much different from those on the surface which were responding well to physical beneficiation. Jaduguda is today supporting a modern uranium mine and a mill. It may be noted that Jaduguda is the first non-ferrous mine to go into production after Independence.

The effort that goes into bringing an area upto the mining stage is enormous. The first step involves the geologist, who has to work often in hostile environment, sometimes troubled by wild animals, sometimes by the Himalayan heights and the extreme cold, or the dust and heat of the desert. Under such conditions, when he is living in more or less complete isolation, cut-off from civilization, his only joy is when he sees the upward swing of the needle of the radiation detection instrument. His first reaction to this record of high reading, which may have come after weeks or months of hard physical and mental effort, is that he has struck a bonanza. And that is when the trouble starts. More than the answers known to the enthusiastic young man are the big questions, like he grade, extent, potentiality, etc, hich worry him all the time. At this uncture only his strong optimism ustains his enthusiasm for work.

---

* A level or nearly level tunnel driven into a hillside for exploration

After a radioactivity anomaly is ocated, the process of evaluation starts. he disposition of the ore body on the urface, and behaviour at depth are tudied. The former includes decipherng two dimensions of the ore-body at urface, *viz.* length and thickness. This done by cutting trenches across the trike; and the third dimension *i.e.* the epth-wise behaviour, is tested by subsurface investigations, including boreole drilling.

An ore body with a minimum strike ength of 1000 metres, and a minimum rue thickness of 1.2 metres is consilered essential to prove a minimum eserve of 1000 tonnes of uranium xide to a depth of 300 metres, with an verage grade of 0.1 per cent $U_3O_8$. o achieve a reasonable level of confience, drilling of the deposit is carried ut on a well-determined pattern, eeping in mind the geological setting nd structure of the area. With the orehole interval of 60 to 120m, and ore size of 32-62 mm for collection and tudy of samples, the confidence level of the order of ±30 per cent. Reserves hus proved fall under the category of ' Indicated " or, in terms of the accepted practice of the International Atomic nergy Agency, under the category ' Reasonably Assured Resources " RAR).

EVERYTHING does not go as per calculations, as the earth's history s not as simple as to be understood merely by some surface/sub-surface work. Many surprises await the explorng geologist, and he has to continuously take stock of the emerging picture with increasing depth with regard to the ore characteristics, radioactive equilibrium-disequilibrium conditions, the behaviour of the ore-body, etc, and keep making mid-course corrections to his exploration strategy as and when necessary.

This process of evaluation carried out by AMD in the case of Jaduguda gave accuracy within -7 per cent with regard to the grade, and +10 per cent with regard to the tonnage (due to over-breakage in mining) as proved by subsequent mining by the Uranium Corporation of India Ltd. (UCIL). Experience at Narwapahar and Bhatin (also in Bihar), has also been similar as proved by subsequent underground exploratory development. This has enhanced our confidence in the method of evaluation of mineral property, calculation of ore reserves, etc, and the results are completely reliable for taking investment decisions.

Later steps bring in other disciplines also and each investigator has his own yardstick to evaluate the deposit. The mining engineer is satisfied with regard to the reserves contained in the deposit only after the deposit has been developed fully and the ore body is available for sampling from 4 sides *i.e.* the level drifts and inclines.

The chemical engineer and the ore dresser are satisfied only if they get a truly representative sample of the ore body to enable them to finalise the flowsheet. Collection of such a sample involves exploratory mining work which may be by means of aditing or shaft sinking. Till this stage is reached, the regular mining man does not appear on the scene and the geologist is left to nurture his baby deposit. For him, it is still the 'wait and see ' stage. It is only after the results of laboratory investigations are available and the deposit cleared by all the scientists connected with the project, that the deposit gets transferred to the mining engineers for commercial exploitation. Thereafter, the geologist has the work of guiding the working faces.

From experience elsewhere in the world and statistics available from other countries, it is seen that out of the initial 2000 radioactivity anomalies, only 200 warrant detailed evaluation. Of these, only 20 may prove to be worthy of being considered deposits. This is one of the reasons why while several discoveries are announced, only a few, about 1 per cent of them, come to the level of a producing mine.

TO sustain the geologist's effort in the field, AMD physicists have contributed significantly in developing sophisticated equipment for uranium prospecting. Gamma-ray spectrometers with crystal size in several thousand c.c., with facility for simultaneous recording of radioactivity due to uranium, thorium and potassium sources, have been taken to the field. And, logging techniques have been perfected and work on spectral logging equipment is in hand.

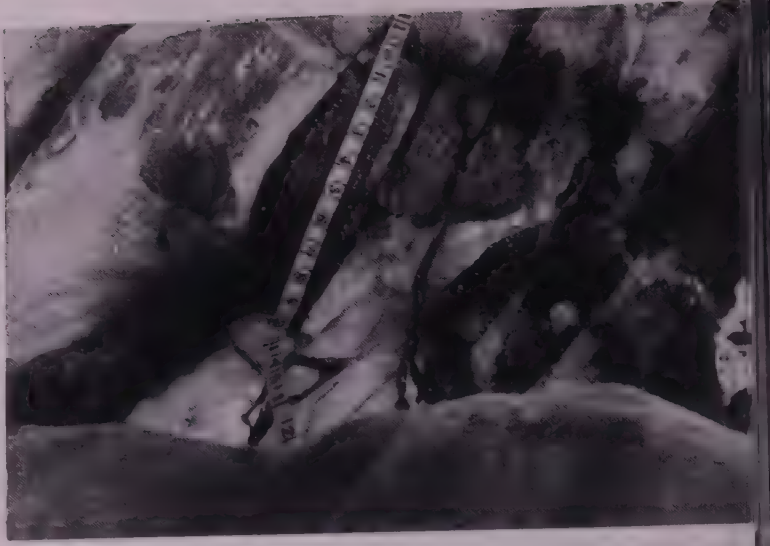
The effort in the field is backed by effective laboratory support to provide timely feed-back of analytical data, which is vital for determining further courses of investigations.

Petrological investigations on ore samples not only tell the characteristics of the minerals responsible for radioactivity, but also throw light on the associated minerals which determine the leachability characteristics. Still more is learnt of the genesis of uranium, the paragenesis *i.e.* the order of formation of various minerals in ore, and the factors favouring localisation of uranium in a particular environment, which helps in selecting favourable areas elsewhere. The mode and controls of mineralisation are also better understood by this study.

Emission and fluorescence spectroscopy help in qualitative and quantitative determinations of minor and trace elements and any other elements which may be associated with uranium in ores and could be recovered economically as a by-product. Precise mineral identification and crystal studies by X-ray defractometry help in geothermometry *i.e.* the temperature of formation of various minerals, and also assist the chemical engineer in finalising the methodology for extraction of uranium.

With uranium we seem to be dealing with a highly mobile element which can migrate from one geological environment to another with utmost ease by simple ground water action, with slight variation in Eh/pH conditions. In mobility, uranium is next possibly only to oil, but unlike oil, the traps for uranium localisation have not only to be structurally favourable but also suitable physico-chemically. Even with an ideal structural setting, the un-

(*Continued on page 6*)



**Top: Primary uranium vein in quartzite — Mahasu distric Himachal Pradesh.** Left: **Adit No. 4 of the Jaduguda Min in the Singhbhum district of Bihar**

# Tremendous Scope for Discovery

(*Continued from page 5*)

suitable pH of the system can leach away the uranium, leaving behind a barren trap.

Our investigations in the Himalayas have established beyond doubt that the granites of Kinnaur in Himachal Pradesh are uraniferous. Rich concentrations of uranium as primary veins in the joints and fractures of Chhinjra Shakiran-dhar area in Kulu district and Rampur area in Mahasu district, Himachal Pradesh though spread over a vast area, do not hold enough reserve to sustain long term production. Mineralisation in the Tunji-Pokhri area of Garhwal district, Uttar Pradesh is associated with copper and is of low grade and discontinuous at depth. These uranium-rich rocks of the Lesser Himalayas are the provenance for the tertiary sediments, namely the Siwaliks, developed at the foot hills. Significant indications have already been located in the Siwaliks. Location of a suitable structural-cum-geochemical trap may be the key to locating a sizable uranium deposit in this environment. Detailed investigations of the sediments on and below surface have revealed that the rocks have been dissected by faults thereby exposing the lower members in the valleys adjoining the tributaries, and opening channel-ways for migration and partial loss of uranium by leaching.

Our hopes in the Siwaliks are Asthotha and Romehra in the Hamirpur district of Himachal Pradesh, where not only are suitable structural traps available but also proper physico-chemical conditions conducive to localise uranium.

TO summarise, the Himalayas have a great potential. Where all the uranium is localised is a question which persistent effort in the coming years alone can answer. Radioactivity anomalies have been detected throughout the Himalayas—from Jammu in the west to Assam and Nagaland in the east, through Himachal Pradesh, Uttar Pradesh, Nepal, Darjeeling, etc. In view of the vastness of the area and the inaccessibility of several tracts, the strategy has been to go from the known to the unknown. In addition to Romehra-Asthotha areas of Himachal Pradesh, the Darjeeling area of West Bengal appears for the present to be our best bet.

In the Peninsular region of the country, our success has been fairly reasonable and satisfying. Several kilometres of drilling in the Singhbhum district of Bihar for over two decades has established reserves enough to meet the requirements of our nuclear programme. Several low grade dep
which are considered uneconom
presently, may become economi
viable in the time to come in viev
the changing price trend in the in
national market.

With the depletion of some of
richer grade ore reserves, particul
in the U.S.A., some rise in the p
can be expected. But forecast of pr
going as high as $1100 per kg
some cases, though alarming, may
be taken as such, as they are gover
by certain international compulsi

The structurally controlled depo
of Bodal in Rajnandgaon, Mad
Pradesh, is in a fairly advanced st
of evaluation by diamond drilling
holds very good promise. Ano
promising area, Dumhath-Jajawal
Sarguja district of Madhya Pradesh
in preliminary stages of exploratio

Our effort of over a quarter cen
has also placed us in a comfort
position with regard to other nuc
raw materials *viz*. thorium, zirconi
beryllium, columbium-tantallum, et

With many tracts still to be inv
gated and a vast part of the cou
still remaining unexplored, there
tremendous scope for discovery
better grades of ore in the country

# Two Decades of the Dubna Nuclear Centre

A little over twenty years have passed since the Joint Institute for Nuclear Research (JINR), the international scientific centre was established at Dubna near Moscow.

After the Institute's creation, a Laboratory of Nuclear Reactions (with a cyclotron for accelerating heavy ions) and a Laboratory of Neutron Physics with a fast neutron pulse reactor were started. The cyclotron and the reactor went into operation in 1960. A laboratory of Computing and Automation, and a Department of New Methods of Acceleration were set up in 1966 and 1968 respectively.

Today, the Institute is one of the largest in the world with over 6,000 scientific personnel employed in it. Because of their size and scope of work, each of the laboratories may well be considered an institute itself. The scientists of the Institute have carried out a series of important investigations in a wide region of modern science: theoretical physics, elementary particle physics, nuclear and neutron physics and in the development of accelerator techniques and physical apparatus.

The Institute makes available to the IAEA fellowships for training physicists from Member States of the Agency.

**op: The U-300 cyclotron accelerates ions of elements from carbon-12 to zinc-66 with an energy of about 10 MeV per nucleus.**
**ottom: The synchrophasotron, the largest accelerator at the Institute, accelerates protons to 10 GeV, deuterons to 11 GeV and articles to 22 GeV**

# Garter Springs

*(Continued from page 1)*

springs required for Reactor No. 1 of the Madras station have already been delivered. All the tools, jigs and fixtures for coiling heat-treatment, welding and inspection were also designed and fabricated by these units.

Being structural bearing elements in the reactor core, these springs are subject to heavy radiation as well as thermal and mechanical stresses. In their manufacture therefore very stringent quality specifications have to be adhered to. Besides going through conventional tests like those relating to chemical composition, mechanical property etc. and eddy current inspection, the rectangular wire is also inspected for corner radius before coiling. Rigorous hardness checks of the springs and meticulous examination of pitch, residual extension and even overlap of girdle wire in the weld zone are carried out to meet the specifications.

Though springs of various engineering materials are available commercially, the manufacture of garter springs with rectangular wire wound on edge, was a challenge beyond the scope of commercial spring manufacturers. ●

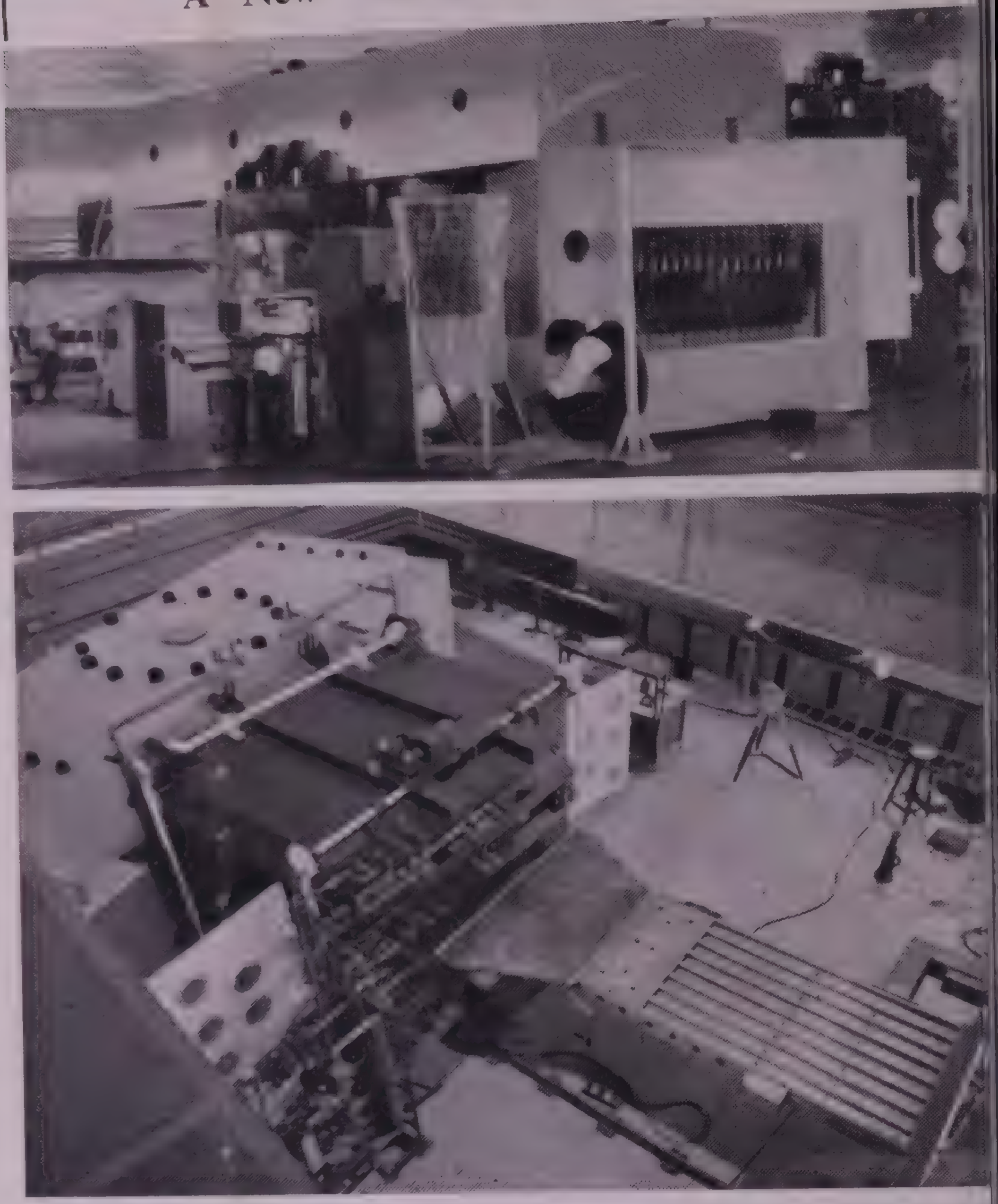
**STATEMENT OF OWNERSHIP**

Place of Publication: Dept. of Atomic Energy, CSM Marg, Bombay 400 039. Periodicity, Publisher's Name, Nationality and Address: Monthly, Jagannath Sharma, Indian, Dept. of Atomic Energy, CSM Marg, Bombay 400 039. Printer's Name, Nationality and Address: Jagannath Sharma, Indian, Dept. of Atomic Energy, CSM Marg, Bombay 400 039. Editor's Name, Nationality and Address: Jagannath Sharma, Indian, Dept. of Atomic Energy, CSM Marg, Bombay 400 039. Name and Address of the Owner: Govt. of India, Dept. of Atomic Energy, CSM Marg, Bombay 400 039.

I, Jagannath Sharma, hereby declare that the particulars given above are true to the best of my knowledge and belief.

(Sd.) JAGANNATH SHARMA
March 1, 1977.

## A New National Research Facility



**THE VARIABLE ENERGY CYCLOTRON at Bidhan Nagar, Calcutta is**
**tional facility for advanced work in nuclear physics, and for the controlled**
**irradiation of biological and agricultural products. It is now getting readied for**
**missioning. The Cyclotron is an indigenously made facility, with a number of p**
**and private sector companies participating in its fabrication. The design of the C**
**tron is based on the 88″ cyclotrons at the Lawrence Berkeley Laboratory and a**
**Texas A & M University in the USA, with some modifications. The top picture s**
**the 262 tonnes main magnet with one of the probes. In the bottom picture is sho**
**view of the dee dee-stem assembly withdrawn from the resonator tank.**

# Hot Cell Cranes

*(Continued from page 3)*

before giving clearing it for installation by the firm.

An imported crane of 1 tonne capacity costs around Rs. 10 lakhs. BARC's effort has cost just Rs. 2.5 lakhs for a 2 tonne capacity unit, without
foreign exchange expenditure.
effort has also given BARC the
fidence to embark on meeting
requirements of higher capacity c
*viz*. 6 tonnes, which will be neede
the future.

**—R. J. Vyas, Cent**
**Workshops, BA**

Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India, Chhatrapati Shivaji Maharaj Marg, Bombay 400 039, and printed by him at G. Claridge & Co. Ltd., Bombay 400 001.

Registered No. R. N. 90

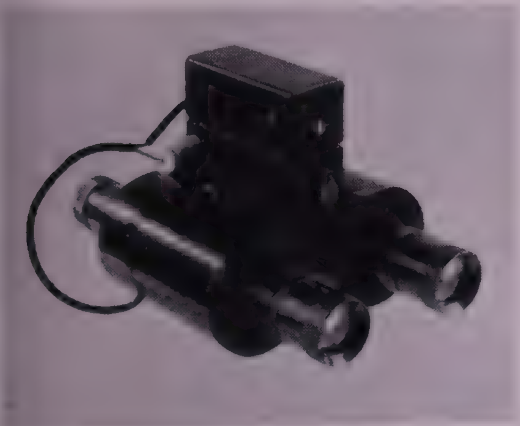
NUCLEAR INDIA
VOL. 15 No. 8 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY APRIL 1977

*A Device for Seeing in the Dark*

# Trombay's Night Vision Binoculars

NIGHT vision binoculars, a lightweight portable device which enables one to see in the dark has been developed and fabricated by the Optoelectronics Section of the Bhabha Atomic Research Centre.

The principle of operation of the binoculars involves conversion of the infrared "illuminated" scene, invisible to the naked eye, into a visible output with the help of infrared sensitive image converter tubes. The binoculars incorporate a miniature power source run on pencil type torch cells which are readily available in the market. All the components of the binoculars were developed indigenously.



In operation, the infrared "illuminated" scene is focused on to the photo-cathode of the image converter tube by means of a lens combination, and converted into a visible image on the screen of the image converter tube. Through an eye-piece the scene appears as it would to the naked eye under normal light conditions.

**Radioactive Halos—pages 4-5**
**Climatic Change—pages 6-7**

The present model has an overall magnification of unity, *i.e.* the size of the image seen through the binoculars is exactly as it would be if seen directly. The unity magnification provides the "usual" night driving situation to the driver. The head-lamps of the vehicle, however, have to be fitted with an infrared filter to cut off all visible light, and thereby make the surroundings completely dark.

With appropriate modifications in the lens system, this device can be used for many other applications. A monocular version of the device can also be designed for other uses, particularly for security and surveillance purposes.

**Some salient features of the night vision binoculars**

| | |
|---|---|
| 1. Field angle | 30° of arc |
| 2. Focusing range: | 2 m to infinity |
| 3. Weight | less than 2 kg |
| 4. Magnification | unity |
| 5. Power supply | battery operated (4× 1.5 volt. pencil torch cells) |
| 6. Interpupillar distance: | adjustable |

7. The device incorporates BARC D-2201 type of image converter tubes.

# *TIFR Experiment On Board the First Spacelab*

A COSMIC ray experiment from India will be on board the first spacelab mission scheduled for earth orbit during 1980.

The experiment was proposed by the Tata Institute of Fundamental Research (TIFR), Bombay to the National Aeronautics and Space Administration (NASA) of the USA in response to its invitation in May 1976. Leading space scientists in many parts of the world had been invited to propose experiments for the Mission.

The first spacelab mission is being jointly developed by NASA and the European Space Agency (ESA). The TIFR experiment is among the 32 selected by NASA and ESA during February 1977. The experiments cover broad areas of space sciences such as astronomy, astrophysics, atmospheric sciences, life sciences and earth observations.

The first spacelab mission will be launched with the first space shuttle vehicle during 1980. The spacelab will orbit the earth for about 7 days and will be brought back for detailed analysis. This mission will mark the beginning of the new programme of space exploration by NASA using a reusable space shuttle vehicle.

The Indian experiment, titled "Studies on Ionisation States of Solar and Galactic Cosmic Ray Heavy Nuclei", is designed to measure some new properties of solar and galactic cosmic rays which have not been studied so far. The investigators intend

(*Continued on page 8*)

## *The Giant Halos Are Still a Mystery*

*(Continued from page 5)*

completely ruled out. There are some suggestions that they may be due to the migration of $\alpha$-radioactivities such as radon from the inclusions to neighbouring areas acting as new centres of halos thereby expanding the radii of the halos. This is not yet proved and I suggest that this could possibly be checked by inducing artificial halos with $\alpha$-activity from a laboratory source—one of the component being $\alpha$-emitting radon in equilibrium—and seeing whether giant halos can be formed. However, it may be difficult to reproduce the geological environments in the laboratory, which could have been responsible for the formation of giant halos.

Halos in minerals like mica have fascinated the scientists of the nineteenth century for a long time. It was the discovery of radioactivity that solved the puzzle. Giant halos are still a mystery and it is hoped that they may give rise to some new discovery or some other discovery may solve the problem of giant halos. Until then we can only wonder at them. ●

# ECIL Completes a Decade of Pione

THE Electronics Corporation of India Ltd. (ECIL), a Government of India undertaking under the Department of Atomic Energy, has completed a decade of its existence. It was set up at Hyderabad in April 1967 with a capital of Rs 10 crores to take up the manufacture of electronic products developed at the Bhabha Atomic Research Centre, Trombay. Since then the ECIL has forged a path of self-reliance and has put on the market a large range of products of use in nuclear power generation, process industries, defence, railways, communication, medicine, research and education. The Corporation manufactures 250 diverse electronics products — all designed and fabricated with indigenously developed knowhow. During these 10 years, the Corporation has helped the country save foreign exchange worth Rs 40 crores by manufacturing advanced electronic products not available in the country. During 1976-77 alone, ECIL developed over 30 new products and had a sales turnover of Rs 28.50 crores.

ECIL has made remarkable progress in the computer field. In a short span of five years the Corporation has installed over 95 computers — for scientific, real-time and commercial data processing applications. Today, one out of every four computers operating in India is made by ECIL. During 1976-77, the Corporation installed 25 computers valued at over Rs 5 crores. It also recently supplied computer systems to the police departments of Tamil Nadu, Maharashtra, West Bengal, Karnataka and Andhra Pradesh for processing criminal record data, and thereby introducing the use of computers for quick detection of crimes for the first time in the country.

ECIL has very recently introduced the fourth generation micro-computers which will find use in areas like traffic control, data communication and navigation.

### *New Developments*

Among the important products developed in recent years are the following :

- A pilot rescue beacon, useful as a communication aid for a pilot in the event of an air crash, or on his being marooned. The beacon starts functioning automatically the moment the pilot bales out of his aircraft. The beacon gives out a distress signal on the international frequency so that a search party may easily identify and locate him. The beacon can also be used in lifeboats and other maritime aircraft where the risk of being marooned is high.
- A densitometer which is used for quick and precise measurement of optical densities of photographic and radiographic films. This is of great use in the photography industry, hospitals and motion picture industry.
- An " Automatic Message Switching System (AMSS), developed for the first time in the country. The AMSS, based on the Stored Programme Control (SPC) Telex Exchange consists of ECIL's computer. It is intended for use by the Overseas Communication Ser-

### Atomic Energy Commission

The Atomic Energy Commission has been reconstituted with effect from April 2, 1977. For the year ending Dec. 31, 1977, the Commission will consist of the following members :

| | | | |
|---|---|---|---|
| 1. | Chairman (ex-officio) | Dr. H. N. Sethna | Secretary to the Government of India, Department of Atomic Energy. |
| 2. | Member for Finance and ex-officio Secretary to the Government of India in the Department of Atomic Energy in financial matters | Dr. Manmohan Singh | Secretary to the Government of India, Department of Economic Affairs, Ministry of Finance. |
| 3. | Member for Research and Development | Dr. R. Ramanna | Director, Bhabha Atomic Research Centre. |
| 4. | Member | Shri V. Shankar | Principal Secretary to the Prime Minister. |
| 5. | Member | Shri Mantosh Sondhi | Secretary, Dept. of Heavy Industry, New Delhi. |

Shri R. C. Sharma, Director in the Department of Atomic Energy is the Secretary to the Commission.

# ing Work

vice for its gateway centres at Delhi, Madras and Calcutta. The SPC Telex-Exchange will help relieve a stagnation of 6.8 million paid minutes in the international telex traffic.

When integrated into the communication network, the AMSS will route messages to appropriate destinations without manual intervention and without delay. The advantage of the system is its capacity to carry out complex routing, monitoring and other operations called for by the transmission procedure. Where routine is a function or order of priority, the message having a defined urgency rating or top priority status is despatched before messages of a lower priority order.

### *Support to Industry*

The Corporation has supplied control instrumentation for the Rajasthan Atomic Power Station and is working on the control equipment, valued at over Rs 5 crores, for the Madras Atomic Power Station. Besides, ECIL is also supplying control instrumentation for allied projects of atomic energy like the Fast Breeder Test Reactor at Kalpakkam, and the heavy water projects at Kota and Talcher.

With the technology generated by the manufacture of instrumentation for nuclear power plants, ECIL has diversified its product range and is in a position to supply custom-built instrumentation to meet the needs of fertilizer, petro-chemical, cement and steel plants. ECIL has already supplied process control instrumentation to leading organisations such as the Fertilizer Corporation of India, the Indian Petrochemical Complex, Bharat Heavy Plate and Vessels etc.

ECIL fabricated and erected the 29.56 m. antenna at the Overseas Communication Service Station, Dehra Dun which links up India with the rest of the world for instantaneous global communication.

With a view to bringing about import substitution, ECIL today makes a series of detectors which are used in nuclear power plants. ECIL is the first to take up their manufacture in India. ●

## A Novel Energy Conversion Process

# *Work in Magnetohydrodynamics in India*

WORK on an experimental magnetohydrodynamic (MHD) plant is being done in India by the Bhabha Atomic Research Centre (BARC) and the Tiruchirapalli division of BHEL in cooperation with scientists from the Soviet Union.

The MHD method relates to the direct conversion of thermal energy to electrical power. This technology is expected to improve the thermal efficiency of fossil fired power plants from the present 30-40 per cent to 50 per cent and even higher. The plant will operate at a level of 5-15 MW (thermal) and will be based on coal technology as India has large reserves of coal, and the technology of coal gasification is available in the country.

What are the merits of the magnetohydrodynamic method of conversion of energy? In the combustion chamber of the MHD plant, organic fuel — gas, oil or coal — is burnt to produce plasma. With the aid of a pre-heated oxidiser — air saturated with oxygen, or pure oxygen itself, plasma with a temperature of more than 2,500°C is generated. To increase the plasma's electrical conductivity, ionised substances such as salts of alkaline metals are added to it. The plasma then enters an MHD channel, *i.e.* a special pipe placed in a magnetic field. In a conventional generator, an electric current is generated due to the crossing of the magnetic lines of force by the rotor's copper conductors. In the MHD plant ionised plasma flowing in the channel at a speed of 800 metres per second and even higher, and crossing the magnetic lines of force serves as the conductor. An electric current appears in the plasma. Since the MHD plant has no moving parts there are no mechanical losses in it. Upon leaving the channel the plasma still has a temperature of more than 2,000°C. If it is then directed into a conventional steam generator, it will be possible to obtain an additional electric current by means of ordinary turbo-generators as is done in thermal power stations.

### Fuel is Saved

As stated earlier the efficiency of the best thermal power stations is 38 per cent, or a maximum of 40 per cent. If we add the MHD-station to the ordinary thermal power station, the overall efficiency will go up to 50 or even 60 per cent. This will save fuel and considerably reduce the ejection of combustion products into the atmosphere.

The USSR has set up a number of experimental MHD plants, and at one of its pilot plants, a design capacity of 20,000 kilowatts has been obtained. ●

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# Sri Hari Om Award for BARC Scientist

DR. Bhupendra Patel of the Bhabha Atomic Research Centre (BARC), has been selected for the "Sri Hari Om" Award for the year 1976-77. Dr. Patel is working in the Health Physics Division of BARC. The award has been given to him for his work in the field of "Oceanology" during 1971-75.

Dr. Patel joined the Bhabha Atomic Research Centre in 1963 after a short spell at the Marine Biological Laboratory of the Annamalai University (1961-63). Since then he has specialised in the field of Aquatic Radioecology, studying the problems of radioactive and thermal waste discharges in the coastal waters, especially the distribution of various radionuclides and their impact on the marine ecosystem off the west coast of India. Earlier, in 1955, he worked with Prof. D. J. Crisp, FRS, at the Marine Science Laboratories of the University of Wales, UK on the problems of thermal tolerance and other physico-bio-chemical environmental factors determining the distribution, functional morphology and physiology of the inter-tidal organisms in the coastal waters of the British Isles.

He was awarded D. Phil. by the University of Wales in 1959. ●

# Radioact

by Dr. V. S. Y
Tata Institute of Funda

**Observed more than a century ago, the**
**the discovery of radioactivity. Recent**
**could be due to the presence of super-h**
**revived interest in Radioactive Halos.**

RADIOACTIVE Halos (also called Pleochroic Halos) are usually small regions of colour or colour differences found around certain mineral inclusions* such as monazite (Ce, La, Th) $PO_4$ in minerals like mica. It was first observed as early as 1873 by Harry Rosenbusch in the mineral cordierite, and subsequently found in many other minerals. The name pleochroic halos is due to the pleochroic discolouration shown by the halos if they occur in doubly refracting substances. (Pleochroism is the appearance of different colours in different crystallographic directions.)

The halos are usually found around small inclusions — a few microns in size — of zircon, allanite, monazite and other minerals that contain an appreciable amount of uranium or thorium. Halos have been found in typical rock forming minerals like amphiboles, pyroxenes and micas. The halos in general are circular when a section of the material is seen under an optical microscope, with a diameter of about 40 microns (0.04 mm).

### Ring Structure

Even though the halos were discovered more than a century ago, their origin was a mystery until the discovery of radioactivity. It was J. Jolly (in 1907) who proposed that the halos are due to the irradiation of alpha particles from mineral inclusions containing uranium and thorium. This simultaneously explained the famous ring structure of the halos as due to different energies of the alpha particles from uranium and thorium series. Whereas the dark inner ring is the contribution of all the alpha particles, the outermost lighter ring is formed only due to the effect of the highest energy alpha particles.

A clear demonstration that pleochroic halos were indeed due to alpha particle irradiation over geological periods of time came when E. Rutherford produced these halos artificially in minerals by bombarding them with particles from alpha emitting nuclides.

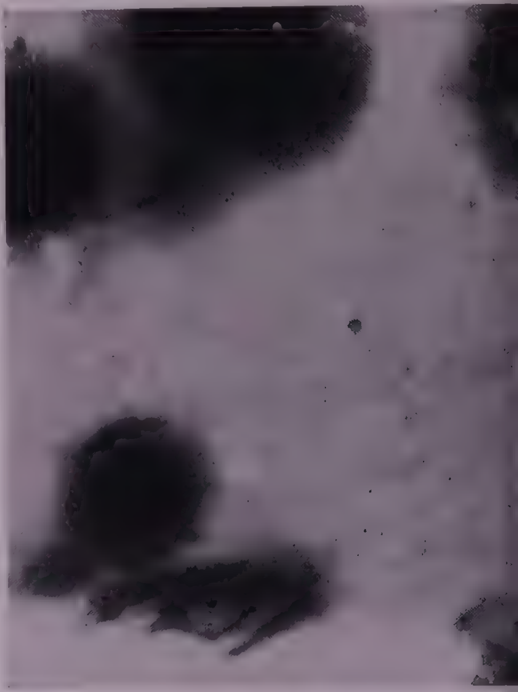
The formation of halos, which are some sort of discolouration in the material surrounding the radioactive inclusion, is due to the damage caused by intense radiation on the crystal structure. The halos may get reversed to their original form if heated or even due to prolonged exposure to $\alpha$-radiation. The radii of various ring structures have been measured accurately and it has been found that they correspond to different energies of alpha particles emitted by uranium, thorium and their daughter products thereby confirming the theory.

The halo colouration appears only after an irradiation with a threshold dosage. It was found that at least $10^{13}$ $\alpha$-particles/cm$^2$ are required to initiate the colouration in the laboratory.

The intensity of a halo in a mineral depends on the amount of uranium or thorium (which emit alpha particles) and the age of the minerals (which is the time of solidification). Since the damage is a cumulative effect, the intensity of the halo is proportional to the age. Radioactive halos incidentally, were used by petrologists to determine the ages of rocks. This method however has a large measure of uncertainty as the intensity of halos also depends on the nature of the materials (different micas differ widely in their sensitivities), and the environment in which they exist, as also the history of the specimens. For instance, as mentioned earlier, heating of the specimen would diminish the intensity of halos thereby giving an apparently lower age.

RADIOACTIVE halos were thus the property of some devoted geologists and petrologists until it was found that there were some anomalous halos in certain minerals, particularly mica. In mica there were some ring structures which could not be explained by any known alpha radioactivity. Many of the anomalous halos found were of course explained as due to one or the other radioactive daughter product of the uranium series, such as polonium or radium.

Mica is usually chosen for the study of halos because it forms thin transparent flakes in which the halos can be studied with comparative ease.



**Radioactive halos in mica produced b**
**thorium. Whereas the dark central**
**$\alpha$-particles of all the energies, the ou**
**energies of $\alpha$-particles. The dimensio**
**millimeter.**

Occasionally giant halos have been observed with diameters so large that it requires energy of alpha particles that is very much beyond any of the known alpha emitters. These halos have radii greater than 50 microns, and sometimes as high as about 100 microns. Since no isotope of known alpha emitters give alpha particles of energy greater than about 12 MeV, these halos have been attributed to some unknown elements. Of course, the giant halos are not a new phenomenon — they were discovered as early as 1924. However, the problem of giant halos was brought into focus by Dr. R. V. Gentry who is devoted to the study of these halos. The reason for their coming into prominence is the exotic suggestion (though plausible) that they could be due to high energy $\alpha$-particles from the decay of some superheavy elements.

Recent theoretical development in

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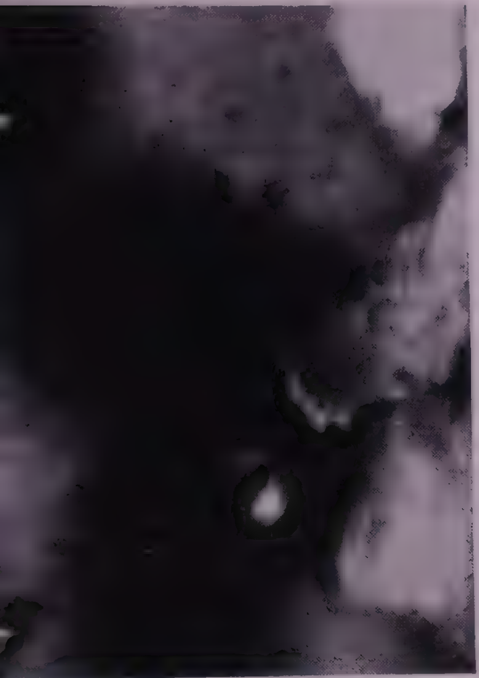
* A foreign body (gas, liquid, glass or mineral) enclosed by a mineral

# e Halos

**varadan**
search, Bombay

**certain minerals were a puzzle until ions that some giant halos in mica ments in the mineral inclusions has**



**al inclusions containing uranium and are due to intense bombardment of er rings are due to increasingly higher e halos are about less than 1/20th of a**

nuclear physics point to the possibility of an island of stability of superheavy elements around $Z = 114$ with sufficiently long life, even to the extent of near stability. On the contrary, transuranium elements beyond plutonium are very short lived and elements beyond 105 are expected to have half life of at most a few seconds, and they decay mainly by spontaneous fission. (The latest confirmed transuranic element goes up to $Z = 106$. Recently, there has been a claim of finding a still heavier element with $Z = 107$ by George Flerov from Dubna, USSR. If confirmed, it will be the highest man-made element so far.) The possibility of superheavy elements in nature has prompted investigations by a number of experimentors working in different fields. Superheavy elements have been looked for in terrestrial ores, ocean sediments, lunar rocks and in meteorites and similar common and exotic materials.

My colleagues and I at the Tata Institute of Fundamental Research proposed, a few years ago, that some of the long fission tracks seen in meteorites and lunar material are due to superheavy elements that could have existed during the formation of the solar system. (*Nature*, *230*, 219-224, 1971.)

IF the pleochroic halos are due to some superheavy elements, it adds a new dimension to the problem of stability of the superheavy elements. Whereas, our work on meteorites and lunar samples suggested the possibility that superheavy nuclei could have existed about 5 billion years ago, the occurrence of giant halos, if due to superheavy elements, must mean that superheavy elements are nearly stable enough to be present until the formation of the terrestrial rocks, which happened billions of years after the condensation of the solar system. Thus, if the giant halos are due to superheavy elements there will in all likelihood be some still left at the site of the halos.

### X-ray Peaks

Gentry began work to find out whether there are any superheavy elements still left in the material which formed the giant halos. He and his colleagues have bombarded the inclusions which formed the halos in mica samples from Madagascar with a beam of 4.7-5.7 MeV protons from a Van de Graaff generator, and analysed the characteristic X-rays (particularly for $Z > 105$) coming out which give the chemical composition of these inclusions. From the analysis they found certain X-ray peaks which could not be attributed to the normal elements (or due to nuclear gamma rays) but conformed to the energies of L X-rays from elements 116, 124 and 126. These X-ray peaks were observed only in the giant halos and not detected in normal halos, supporting the claim that superheavy nuclides reside in the inclusion which forms the giant halos. The X-rays which identified the superheavy nuclei correspond to the $L\beta_2$ transition in element 116 and $L\alpha_1$ transitions in elements 124 and 126. These transitions were observed only when the targets bombarded with the protons were from the giant halos and not when the inclusions from normal halos were used. In addition, there is also a weak evidence for the elements 114, 125 and 127. The abundance of superheavy elements is estimated to be about $10^{11}$ atoms per inclusion.

This was the situation sometime during the middle of last year when the investigators announced their results. Many scientists were attracted by this announcement and a few of them have come out with their ideas which seem to be in opposition to the idea of these giant halos being due to superheavies. One opposition was to the superheavy hypothesis when it was pointed out that cerium could give the observed X-rays by $Ce^{140}$ (p, n$\gamma$) $Pr^{140}$ when bombarded with protons. This gamma ray energy of 27.23 keV will interfere with the 27.25 keV line expected (and observed) from $Z = 126$. Since, in the original experiment, the presence of X-rays of $Z = 126$ was observed in five out of six cases, the observation that $Ce^{140}$ could give X-rays due to nuclear processes when bombarded with protons of $E > 4.3$ MeV makes the superheavy idea less tenable, particularly due to the fact that cerium is one of the important constituents of monazite. Gentry and his collaborators however are reported to have said that the strength of $Ce^{140}$ (p, n $\gamma$) is insufficient to explain the observed spectrum from giant halos. Hence they maintain their conclusion on superheavy elements.

Other workers have analysed monazite ore from Madagascar and tried to look for elements with $A > 300$ by mass spectrometric techniques without any positive signal. Many other methods, such as chemical separation have also given negative results.

If they are not due to superheavy nuclei, then what are the giant halos due to? Some alternative hypothesis have to be found for the presence of giant halos if the superheavy idea is

(*Continued on page 2*)

# Climatic

**Inspite of man's remarkable advances in technology, ultimately he is still dependent on the Earth's climatic system for food and fresh water. The recent occurrences in certain regions of the world of climatic extremes such as excessive rain or droughts and unseasonably high or low temperatures have led to speculation that a major climatic change is occurring on a global scale. Some point to the recent drop in temperatures in the northern hemisphere as an indication that the Earth is entering a new ice age. Others see a global warming trend that may be due to a build-up of carbon dioxide in the atmosphere. An authoritative report on the subject has been prepared by a World Meteorological Organisation Panel of Experts on Climatic Change. Excerpts from the report are given here.**

FOR about the past 8,000 years, the Earth has been in a comparatively warm interglacial phase of an ice age sequence, with less ice (most of it in the Greenland and Antarctic ice sheets) than at any time in the past 100,000 years. Mid-latitude temperatures are today 5 to 8°C warmer, and sea levels 80 to 100 meters higher than those typical of extreme glacial stages.

Since the recovery of the Earth from the last glacial stage, about 8,000 to 10,000 years ago, the global climate has been found from a variety of paleoclimatic indicators to have fluctuated within much narrower limits. In part the post-glacial climate changes have involved expansions and retreats of polar ice and mountain glaciations, at intervals of approximately 2,000 to 3,000 years, in what is described as a "neo-glacial cycle". The "Little Ice Age", a period of temperatures 1 or 2°C lower than today and stormy conditions in the North Atlantic, lasting from about 1550 to 1850 A.D., was a part of the neo-glacial cycle.

Since the time of the Little Ice Age, the world has generally warmed about 1°C, but the rate of warming has been irregular and it is not certain whether the Little Ice Age has yet run its full course. This warming was especially pronounced during the first half of the 20th century, with temperatures rising most rapidly (several degrees C in 50 years) in the Atlantic sector of the Arctic. Events in the southern hemisphere are less clearly documented.

The climatic trends characteristic of the first half of the 20th century appear, generally speaking, to have reversed direction since then, at least in the northern hemisphere. Temperatures have fallen especially in the Arctic and the Atlantic Sub-Arctic (by several degrees C in some areas) where the extent of sea ice has again been increasing. The atmospheric circulation of the northern hemisphere appears to have reverted to a pattern resembling that of the last part of the 19th century, with a tendency towards greater variability of weather conditions in many areas. These changes may have begun to falter, if not actually to reverse yet again, in the last few years.

Recent years have also ~~witnessed~~ severe drought, as in the Sahelian zone of Africa, shifts of the monsoon belt of the tropics, and other extreme events elsewhere in the world. To what extent such developments are related to one another, as manifestations of a globally coherent and systematic fluctuation of climate, is not clear.

One illustration of the kind of interaction that probably contributes significant variability to the climatic system is that between snow cover, reflection of solar radiation, and air temperature. If a small decrease of temperature occurs which favours the development of a snow cover, the greater reflection of solar radiation from the snow will locally reduce solar heating of the Earth's surface and atmosphere. The reduced heating will then lower air temperature still further, preserving the snow and perhaps favouring additional snowfall over a wider area. A similar, but opposite, chain of events is involved if the starting point is a small increase of temperature. The end effect is both to amplify small climatic disturbances, and to prolong them.

## Effects of man's activities on climate

Many scientists have suggested that man's activities may be responsible in various ways for changes of climate occurring now or in the future. On a local scale, as in urban areas, human effects on climate are a demonstrable reality. The relative warmth of large cities, known as the "urban heat island effect", is a well documented example of such local effects. On larger geographical scales, human effects are generally thought to be small, at the present time, in relation to the magnitude of natural climatic variability. They are, nevertheless, to be recognised as of potentially great importance in altering the natural evolution of large-scale climate over the next century or two.

**A build-up of carbon dioxide in the global atmosphere, already clearly evident in observations around the world and which thus far amounts to at least ten per cent since the last part of the 19th century, is reliably traceable to the combustion of fossil fuels. If most known reserves of such fuels are consumed in the next century or two, as it now seems they may be, atmospheric carbon dioxide concentrations would be likely to increase several fold above present levels. The best information now available indicates that such a large carbon dioxide increase would result in a very significant warming of global climate, by several degrees C and that, because of the slow pace of removal mechanisms, this warming would persist for many centuries after the fossil fuel reserves have been substantially depleted. Further climatic effects, as yet difficult to foresee in specific detail, would also be likely.**

**The heat released to the environment by the generation and use of energy, whether fossil or nuclear,**

NUCL

**for energy increases by a factor of ten or more, which could take place within the next century.**

Further effects of man, for example those attributable to increasing pollution of the atmosphere by particulate materials, and alterations of the upper atmosphere through the effects of contamination by nitrogen oxides or chlorine compounds (such as chlorofluoromethanes), are as yet of relatively uncertain importance to future climate. These matters deserve further investigation.

# *Change*

Other than on a local scale, there is no unequivocal observational evidence that human influences of any kind have yet been the origin of unusual climatic behaviour anywhere in the world. This is not altogether surprising in view of the high natural variability of climate which makes detection of human impacts difficult. Nevertheless there is no justification on these grounds for complacency about the potentially serious effects that man's activities could have in the future.

Knowledge of past climates suggests that the interglacial warmth of the past 8,000 years or so will eventually change to a colder, more glacial regime. The onset of that change may be a number of millennia or centuries away; conceivably it may already have begun. It seems likely that this transition will be sufficiently gradual so that in the next 100 to 200 years it would be almost imperceptible amid the ubiquitous variability of climate. There is however a very small yet finite probability that a much more rapid cooling of climate will occur in the same time period.

It must be recognised that such assessments would be invalid if, as now considered probable, the addition of carbon dioxide to the atmosphere, and other effects of human activities during the next 200 years, contribute to a general warming of global climate. This would probably result in a considerable reduction of the floating sea ice in the Arctic regions. It is pertinent to note that when the sea-ice retreated during the so-called climatic optimum, about 5,000 years ago, there were important shifts of climatic belts in lower latitudes. The general warming could conceivably culminate in the total disappearance of the Arctic sea ice, an extreme situation believed to be without precedent in the past million years.

Present ecosystems and many of the complex, inter-dependent systems developed by modern man are fairly well adopted to the climatic conditions that prevailed in the past, and are therefore quite sensitive to changes in climate. For example, the present systems used for food and fibre production are predicated on average climatic conditions and even a modest change in climate would have serious social and economic repercussions. A cooling of the earth by as little as 1°C could result in a shorter growing season and a shift of the boundary of major wheat production regions, and decrease fish catch and timber production in middle and higher latitudes; in lower latitudes, however, such a change could be beneficial. Similarly, warmer global temperature could result in improved productions in some latitudes and reduced yield in others.

**1 BARC. Patients at the All-India In**
**n being examined with medical equipr**
**ft has her reflex responses checked, and**
**Response Counter. At right the K**

nitrogen oxide, sulphur dioxide, chlorofluorocarbons) and low-tropospheric aerosols;

(d) Extent and albedo of snow and ice at the surface;

(e) Changes in surface albedo over both land and sea, especially with respect to land use patterns, vegetation changes, pollution and biological productivity of the oceans.

Special stress must be given to the need to monitor possible small changes of the extraterrestrial solar radiation, mainly in the visible and near ultraviolet range.

Research is also needed for a better adaptation of man's activities to climatic variability and change. This is especially true regarding the need for increasing agricultural production and regarding the impact of energy use on local, regional and global climatic conditions.

The Executive Committee of the World Meteorological Organisation has approved the following statements on climatic change and its study:

- Although in the long-term, a major *natural* change to a different climatic regime must be expected, it is unlikely that any trend towards such a change would be perceptible in the short-term, as it would be obscured by the large shorter-term climatic variability;
- The shorter-term natural or possible man-made changes in climate are of immediate concern, because of their important impact on human welfare and economic development;
- An improved ability is needed to predict short-term natural changes in climate to enable governments to consider appropriate action;
- Improved understanding of and improved ability to predict the impact of man's activities on the global climate is needed in view of their possible consequences;
- Existing knowledge of natural short-term climatic variability, although limited, should be used more effectively in planning economic and social development.

*(IAEA Bulletin, Vol. 19, No. 1)*

## *Spacelab Experiment*

*(Continued from page 1)*

to employ a detector system using solid state particle detectors which have special advantages for exposure in free space for a prolonged period of time. The idea for this experiment originated in the analysis by scientists from the TIFR and the Physical Research Laboratory (PRL), of the results of the cosmic ray experiment on the earlier "Skylab" mission (see *Nuclear India*, Feb. 1975). Several new features of cosmic rays were then observed. The "Spacelab" experiment is designed to measure some of these properties with a more sophisticated detector assembly.

The team of scientists engaged in this experiment consists of Prof. Sukumar Biswas (Principal Investigator), Drs. R. Cowsik, N. Durgaprasad, Jyoti Nevatia, S. Sarkar and V. S. Venkatavaradan (co-investigators) of the Tata Institute of Fundamental Research, Bombay; and Prof. Devendra Lal, Director, PRL (Principal Co-investigator), Drs. J. N. Goswami, U. B. Jayanthi and S. Krishnaswamy of the PRL, Ahmedabad.

This proposal of the TIFR and PRL was sent to NASA through the Indian Space Research Organisation (ISRO), Bangalore which is sponsoring and supporting the programme.

The detector system, the detailed design of which is being made at the TIFR, will be fabricated and tested in the TIFR and ISRO laboratories. Subsequently, it will be delivered to NASA for final testing and integration into the payload system by mid-1979.

The launching is scheduled towards the end of 1980. ●

**Nuclear India**

is a monthly publication of the Department of Atomic Energy, published around the 20th of each month. To ensure prompt attention, all communications should be addressed to the Editor, NUCLEAR INDIA, Department of Atomic Energy, Chhatrapati Shivaji Maharaj Marg, Bombay 400 039. While intimating change of address, the code and number given on the wrapper should be mentioned. Bombay recipients may contact 25 04 77 for prompt action.

# BARC Reporting

### Division of Radiological Protection

Advice on radiation safety measures and planning of radiation installations was provided to 265 institutions in the country in March. An isotope laboratory and two industrial radiography installations were approved for construction. Permission to procure and handle radioisotopes was accorded to 50 medical, 60 industrial and 30 research and agricultural applicants.

* * *

A total of 17,020 radiation workers from 1,777 institutions all over the country were monitored to determine personnel X, β and gamma exposures. About 250 workers in 30 institutions were also monitored for fast neutron exposure.

* * *

Therapy-source loading operations were supervised in three medical institutions and radiological protection survey and inspection visits were conducted in eight institutions during March. Two Gamma-zone monitors, one each of Wide Range Survey meter and Gamma radiography survey meter were also supplied to institutions on request.

### Biochemistry & Food Technology Division

preserving the snow and perhaps favour-ng additional snowfall over a wider area. A similar, but opposite, chain of events is involved if the starting point is a small increase of temperature. The end effect is both to amplify small climatic disturbances, and to prolong them.

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graphical scales, human effects are erally thought to be small, at the ent time, in relation to the magni- of natural climatic variability.

*Pectin from mango waste:* Pilot plant studies on pectin extraction from mango peel was undertaken in the Division. Two kilogrammes of dried peel were used for extraction in a steam jacketed kettle using an acidified water (0.01 N HCl) as an extraction medium. Conditions such as the amount of water, temperature and time required for extraction have been standardised. The extraction procedure was repeated three times to obtain maximum pectin from peel.

The combined pectin extract was then concentrated in a vacuum concentrator to reduce the volume by 25 times to reduce quantity of alcohol required for precipitation. Thus precipitated, the pectin was dried, and powdered for jelly grade study. Jelly grade of pectin from mango peel obtained from this follow-up procedure was found to be 220°. The yield was also in the range of 15-16 per cent on dry weight basis.

### Hi-level Waste Management Section

*Workshop on Waste Management and its Environmental Aspects:* An Indo-German workshop on this subject was held at Trombay, during March. Technical papers on the status of melt-development and process and engineering systems development were presented. Besides, papers on salient features of the Waste Immobilisation Project, Tarapur, and Solid Storage Surveillance Facility, as also the general philosophy of high level waste management were presented by BARC scientists.

The German programme on waste management with particular emphasis on works underway at Karlsruhe, Julich and Asse Salt Mines were presented by the German scientists. Detailed discussions were held on these and environmental aspects of radioactive waste management, and areas of possible co-operation between India and Germany in this field were identified.

Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India, Chhatrapati Shivaji Maharaj Marg, Bombay 400 039 and printed by him at G. Claridge & Co. Ltd., Bombay 400 001.

**Registered No. R. N. 9002/62**

# NUCLEAR INDIA

VOL. 15 Nos. 9-10 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY MAY-JUNE 1977

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**MEDICAL ELECTRONICS FROM BARC.** Patients at the All-India Institute of Physical Medicine and Rehabilitation, Bombay are shown being examined with medical equipment developed by the Electronics Division of BARC. The patient at left has her reflex responses checked, and delays in reflex signal transmission in nerves measured by the Reflex Response Counter. At right, the Knee and Elbow Movement Monitor measures the angular movements of the knee and elbow joints of the patient. Work at BARC in medical and industrial electronics is described inside.

# Transfe

## An India

### April 10-14, 19

NUCLEAR engineers and scientists from developing countries, and some world agencies gathered at Shiraz in Iran during April 10-14, 1977 to discuss a theme with which they are very much concerned today—the transfer of nuclear technology. Among the papers read out at the Conference were seven* from India, contributed by Dr. H. N. Sethna, Chairman, Atomic Energy Commission, Dr. R. Ramanna, Director, Bhabha Atomic Research Centre, Dr. M. R. Srinivasan, Director, Power Projects Engineering Division, and Dr. P. K. Iyengar, Shri K. T. Thomas and Shri A. A. Khan from BARC, Shri A. S. Rao, Managing Director, Electronics Corporation of India Ltd. and Shri K. Nanjundeswaran of the Tarapur Atomic Power Station.

Dr. H. N. Sethna's paper described India's experience in atomic energy, as one which encompassed not only the process of assimilation of nuclear technology from outside, but also the generation of such technology within the country. The industrial infrastructure prepared for fabricating nuclear fuel elements, manufacture of electronic equipment and instrumentation, and the creation of the capability for building nuclear components in the country were cited by him as the direct results of the atomic energy programme's well-defined policy of self-reliance. India has reached a stage when practically all the equipment required for a reactor programme is manufactured by it. The close interaction of research and development activities, pilot plant studies, individual operations and feedback from operating plants to the design and development groups is a feature of the programme which made it successful. Such integration is perhaps unique and has provided considerable strength to the programme.

The success of the programme was attributed to the strategy of development which recognised the fact that a multidisciplinary R & D base is an essential pre-requisite. Besides this was the existence of an inquisitive and sustained scientific base, and an enlightened management structure, a widening industrial base and the policy of encouraging young engineers and scientists. The benefits of pursuing this line of development was all-round improvement in the quality of the other technologies in the country and acquisition of new skills as well as greater confidence. In establishing R & D facilities, short term cost benefit analysis could often be an impediment. Dr. Sethna's paper therefore urged that a long term view be taken of the programme and scientists be given adequate freedom in their planning of R & D activities. The paper underlined the need for a regular training programme. He observed that developments in the nuclear field being so rapid brought the risk of obsolescence in the man involved.

SPEAKING on cooperation in research and development, Dr. R. Ramanna was emphatic that in a nuclear programme in a developing country "a strong research and development effort is not only essential, but inescapable." An R & D base is necessary not only for a nuclear programme, but for any general industrial development planned to bring the developing country to the forefront of modern technology. The most effective benefits of an R & D programme comes about as a result of close collaboration with laboratories of different disciplines and industry within the country as well as neighbouring regions which have common conditions of climate, culture and economic development. Dr. Ramanna explained that the research effort could be organised in several ways, each covering a certain specific need. In developing countries R & D is like a spring-board for modern technological development. These countries can save considerable time and cost by bypassing the steps taken by the advanced countries in their development process. R & D he said, should be viewed as a watch dog against the import of obsolete technology. Basic research stimulated the creativity of scientists. To illustrate the value of basic research, Dr. Ramanna gave the example of neutron beam research at Trombay. While working on a programme to build reactors at Trombay, the scientists were encouraged to use the intense beams of neutrons available for basic research in solid state and nuclear physics. This approach paid rich dividends because, besides other things, the scientists came up with various techniques for characterising materials. As a result, Trombay has a group of experts who have also applied these techniques to metallurgical problems of immediate value. As a byproduct of research in nuclear fission with neutrons, X-ray fluorescence spectrometers have been developed which are now in use in analytical applications by chemists, geologists, and metallurgists.

Trombay's wide ranging programme in neutron scattering has similarly lead to the indigenous development of control systems based on computers, and to the development of ferrites for microwave applications. The study of ferrites by neutron defraction has led to a new understanding of mixed ferrite systems. This has resulted in generating greater efforts in the preparation and characterisation of technologically important ferrites. A group has now embarked on the fabrication of ferrites and garnets used in applications in advanced communications. Yet another development from basic research has sprung from the research group's interest in the development of pulsed neutron sources and detectors for the research programmes at BARC. This has applications in oil prospecting.

Dr. Ramanna also described the effort to assimilate technology in the country by what he called "adaptation research". This kind of "applied research", he said, involved indigenisa-

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*Dr. Sethna, Shri A. S. Rao and Shri A. A. Khan did not attend the Conference.

# of Technology

## iewpoint at Shiraz, Iran

tion of imported designs of complex systems, and adoption of materials and components to suit local availability. In this context he referred to the Variable Energy Cyclotron built by BARC at Calcutta. As a result of indigenisation, only 7 per cent of the total investment of Rs 8.5 crores on the Cyclotron has gone in foreign exchange. A large part of the work of fabricating components and other systems was done by BARC and public sector undertakings. For industrial development in a developing country, Dr. Ramanna said, industry has to show willingness to enter high technology areas under the influence of R & D groups. Industry has been a major beneficiary of R & D work carried out in the field of atomic energy in India.

Speaking about regional cooperation, he observed that the problems facing developing countries in nuclear power development, and the social and economic conditions are strikingly similar. The only sensible thing developing countries have to do is to cooperate in evolving solutions to the problems facing them. India, he said, subscribed to the concept of technical cooperation in developing countries and has made efforts to share its facilities and resources with other countries in the Asian region, especially in the area of utilisation of research reactors. One such collaboration is the five-year India-Philippines Agency (IPA) Project under which India has provided a neutron crystal spectrometer for use in collaborative research programmes in neutron scattering at the Philippines Atomic Energy Commission's facility. India has also cooperated with other Asian countries in building up the capability for producing radioisotopes, and developing applications for them. The institution of the Regional Cooperation Agreement (RCA) in 1972 under the auspices of the IAEA is typical of the success of such cooperative programmes, and India's active role in them.

MANPOWER planning and development for the introduction of high technology is connected with the industrial base and educational and other socio-economic factors, observed Dr. P. K. Iyengar in his paper describing Indian experience on manpower development for the nuclear power programme. In India, manpower training for the nuclear programme started several years before the introduction of nuclear power plants. Groups of engineers and scientists acquired training on research reactors, and in the use of isotopes, nuclear instrumentation etc. at the Atomic Energy Establishment (later the Bhabha Atomic Research Centre) at Trombay years before the commencement of the construction of nuclear power plants. A training school was also started in the beginning for training fresh engineering and science graduates in the varied disciplines under the umbrella of atomic energy. Dr. Iyengar spoke in detail on the BARC Training School which is considered to be one of the important activities under the atomic energy programme. In the training programme, the approach followed by the Department of Atomic Energy has ensured that experienced manpower is not drawn off the industry or other areas of national endeavour. The BARC draws fresh graduates from the universities and makes them specialists in various disciplines under atomic energy. Besides the regular courses at the School, there are short term special courses, refresher courses etc. in varied areas for on-the-job training of engineers and technicians.

Manpower training in developing countries has to be a continuous activity not only for augmenting requirements of personnel, but also to minimise the effects of the brain drain, Dr. Iyengar observed. It is possible that developing countries may readily benefit from nuclear power by a "black box approach" in the immediate short-run. However, this course would not provide for sustained growth necessary for meeting the needs of a rapidly changing technology such as nuclear technology. Like the other speakers from India, Dr. Iyengar also underlined the need for a broad based programme of R & D and manpower development.

Dr. Iyengar also spoke of the effort put in by nuclear institutions in the country to improve scientific research and teaching standards in the universities by interacting with them continuously, with trained scientists from atomic energy units being deputed to universities, and university teachers being exposed to advances in the nuclear sciences through regular summer schools organised by the Department of Atomic Energy. Besides Indian personnel, Dr. Iyengar observed, scientists and engineers from other countries, especially from the South East Asian region have also been trained in this area.

Describing the manpower development programmes at various levels and disciplines in atomic energy and the vast reservoir of trained personnel built thereby, Dr. Iyengar emphasised that the effort was the result of a definite manpower development plan decided at the initial stages of the nuclear programme. Referring to the prophetic words of Dr. Homi Bhabha in March 1944 that "When nuclear

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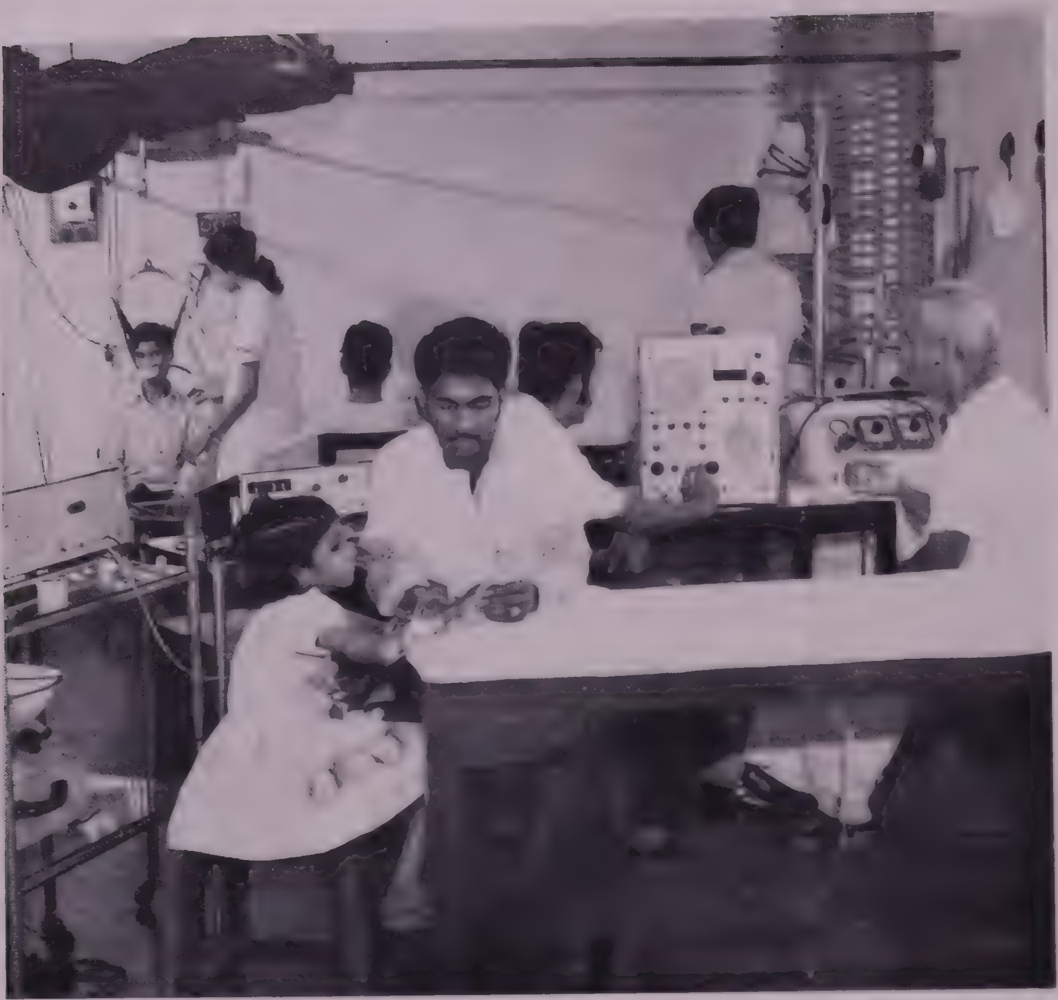


The Electromyograph (EMG), Muscle Activity Monitor and the Action Potential Counter in use in the Rehabilitation Workshop of the All-India Institute of Physical Medicine and Rehabilitation. The EMG is employed for diagnosis of neuromuscular disorders and studies in nerve and muscle physiology. The Muscle Activity Monitor is for training the patient and establishing a dialogue between the patient and the doctor while the Action Potential Counter helps to study day-to-day improvement due to rehabilitative and clinical treatment.

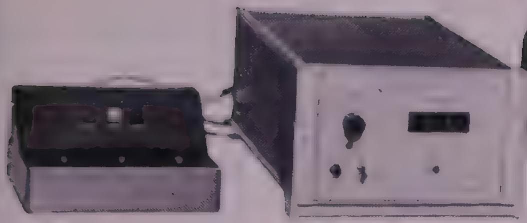
## *Electronics at BARC*

# Work on Test Equipments And Display Systems for Industrial, Medical Applications

**Electronics is among the many disciplines pursued as part of the atomic energy programme. Starting with the Tata Institute of Fundamental Research and continuing with the Bhabha Atomic Research Centre (the erstwhile Atomic Energy Establishment, Trombay), the electronics activity under atomic energy has diversified and even spilt out into the commercial, non-nuclear arena. The Electronics Division at the Bhabha Atomic Research Centre has pioneered major nuclear and non-nuclear electronic development in the country, and has been carrying on R & D work in a number of distinct areas. The BARC has separate sections dealing with specific areas such as Opto-electronics, Laser, Advanced Electronic Instrumentation, Test Equipments and Display Systems, etc. The work at BARC on Solid State Electronics and Nuclear Data Handling was described in the January 1976 issue of *Nuclear India*. Here, Shri V. K. MENON gives an account of the work and achievements of BARC in the area of Test Equipments and Display Systems, which is the responsibility of a section of the Electronics Division.**

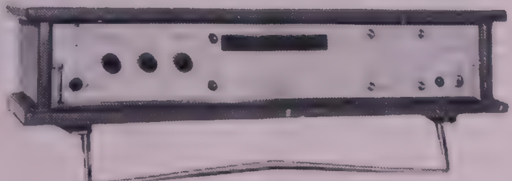
IN 1964, a group of engineers was entrusted with the task of developing oscilloscopes to meet the special requirements of the Defence Services. The successful development and production of oscilloscopes for defence units boosted the confidence of this group of scientists and enabled them, in 1971, to embark into the wider area of solid state instrumentation. Inter-disciplinary coordination was established with various public and private non-profit making institutions and other divisions of BARC (especially, the Atomic Fuels Division and the Medical Division) to exchange and expand the expertise generated, and to develop instrumentation to meet the users' special requirements. Joint projects were taken up with these institutions for developing a range of industrial and medical electronics instruments. Among some of these varied institutions are the KEM Hospital, the J.J. Group of Hospitals, the Sola Hakim Research Centre, Ackworth Leprosy Hospital, Jiyajee Research Laboratories, All-India Institute of Physical Medicine and Rehabilitation, the Victoria Jubilee Technical Institute, Tata Thermal Power Station, and the National Centre for the Performing Arts (all from Bombay). Besides these are the Research, Design and Standards Organisation of the Ministry of Railways at Lucknow, and the All-India Institute of Occupational Health, Ahmedabad. Broadly, the collaboration was towards the development and fabrication of prototypes of test equipment, display systems, industrial and medical instrumentation, and systems for specific requirements.

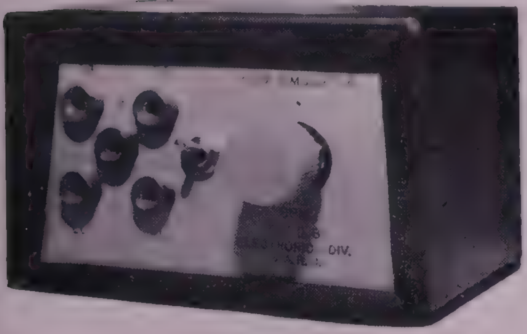
The expertise generated in the field



Reflex response measuring system (Industrial Medicine)

Knee Elbow Movement Monitor for human locomotion studies



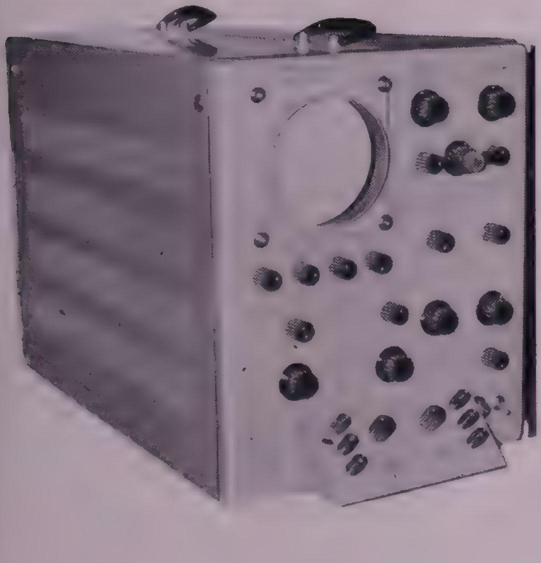


Muscle strength monitor and readout. (Right) Muscle Action Readout. Both the instruments are used for bio feed-back and physiological research

Electrocardiogram (ECG) simulator for calibration of ECG systems

Action potential counter for physical medicine studies

Transistor Curve Tracer



Transistor Curve Tracer Adapter

of instrumentation for bio-feedback and physiotherapic applications, in collaboration with the All India Institute of Physical Medicine and Rehabilitation, has been recognised by the Indian Council of Medical Research (ICMR) who have approved a project on Therapeutic Bio-feedback. The Test Equipment and Display Systems Section of the Electronics Division of BARC has been entrusted with the development of instrumentation for clinical procedure for a Bio-feedback system in an ICMR-sanctioned project.

The BARC has also built some special systems to meet the specific requirement of the users. These systems are described in pages 8, 9 and 10

IN today's world an effective information and documentation service is indispensable for scientific research. The service has to be up-to-date, speedy and efficient to save the researchers' time and avoid duplication of work. The advances in the sciences have been extremely rapid and consequently the information generated has been expanding at an enormous rate. In the nuclear field itself, some 90,000 publications, including journal articles, conference papers, technical reports, theses, patents, books etc. falling within the broad category of nuclear science and technology appear every year; and this number is increasing exponentially. Nuclear Science Abstracts, which was the most comprehensive abstracting journal in the field till it ceased publication in July 1976, listed only 2,500 items in 1948, the first year of its publication. In 1975, it had listed 66,208 items—nearly 26 times the first figure. Today, the total number of scientific and technical publications is conservatively estimated at 2.5 million per year.

## *Information Systems in Nuclear Science and Technology*

The importance of atomic energy prompted many advanced countries to set up their own information systems in the field at an early stage. A number of abstracting and indexing journals, fully or partly devoted to nuclear science and technology, were available by the middle of the nineteen sixties.

**Equipment for making microfiches of publications**

**Micro-filming camera and Prostar processor for preparing 16 mm films for making microfiches and 35mm negative slides**

Among the large national information systems covering nuclear science and technology today are the following:

(i) Technical Information Centre, United States Energy Research and Development Administration (USERDA), Oak Ridge, USA.

(ii) Central Research Institute for Information, Technical and Economic Studies on Nuclear Science and Technology, Moscow, USSR.

(iii) Le Service de Documentation, Centre d'Etudes Nucleaire de Saclay, Commissariat a L'Energie Atomiquc (CEA), France.

(iv) Zentralstelle fur Atomkernergie-Dokumentation (ZAED), Karlsruhe, Federal Republic of Germany.

(v) Division of Technical Information, Japan Atomic Energy Research Institute, Tokai, Japan.

(vi) Library & Information Services, Atomic Energy Research Establishment, Harwell, U.K.

The European Nuclear Documentation System (ENDS) of the Centre for Information and Documentation (CID), Commission of European Communities, Luxembourg, is the largest computer-based information system in the nuclear field in the world. Operating since 1967, its nuclear data base, which consists of over 2 million items, has been built up from Nuclear Science Abstracts and items selected from about 100 abstracting periodicals. The System now contains INIS data base also.

## An Informati

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# *Bhabha*
# *Research*

**By Dr. V. A. Kamath**

*Head, Library & Information Service*

**A view of the BARC Library Hall**

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## International Nuclear Information System (INIS)

The International Atomic Energy Agency (IAEA) has set up the International Nuclear Information System (INIS) at Vienna. This computer-based system, the first of its kind in the world, went into operation in April 1970. Presently, some 64 countries and international organisations are participating in INIS. The inputs received at INIS are thoroughly checked and merged, and magnetic tape containing all the inputs, as well as its printed version, called 'Atomindex', is brought out every fortnight. This is by far the fastest international information service today and is the fore-runner of other international information systems such as AGRIS, *i.e.* International Information System in Agricultural Sciences and Technology, and the proposed 'DEVSIS'—Development Science Information System.

The main objective of INIS is to improve and expedite exchange of nuclear information among nations of the world through multi-lateral cooperation, and to avoid wasteful duplication of efforts in the field. It also aims at meeting the information needs of the developing countries and helping them to train their scientific and technical personnel, thus establishing an infrastructure for their work in the peaceful uses of atomic energy. It is essentially a mission-oriented information system covering more or less the entire field of nuclear science and technology. The uniqueness of INIS is its document back-up service which, unlike other information systems, makes available all the non-conventional literature *i.e.* literature usually not available through normal commercial channels, documented into it.

**Multi-purpose camera-cum-enlarger**

BARC is the national data feeding centre for INIS and the work of preparing the national input, comprising nuclear literature published in the country, is carried out by its Library and Information Services. A small INIS unit consisting of personnel with scientific and documentation background was formed at BARC in January 1970. The work of this unit involves scanning of nuclear literature published in India for items falling within the subject-scope of INIS, and preparing the input as per the rules, standards and specifications laid down by the IAEA. The data from India forms nearly 2 per cent of the INIS Data Bank, which now has over 3,08,000 items.

## Information Services at BARC

The Library and Information Services of the Bhabha Atomic Research Centre ranks as one of the largest information centres in the field of nuclear science and technology, in this part of the world. It was set up primarily to meet the information needs of scientists of the BARC, and its sister organisations in the Department of Atomic Energy.

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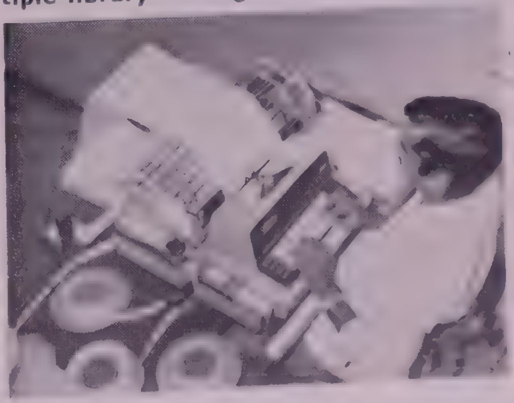
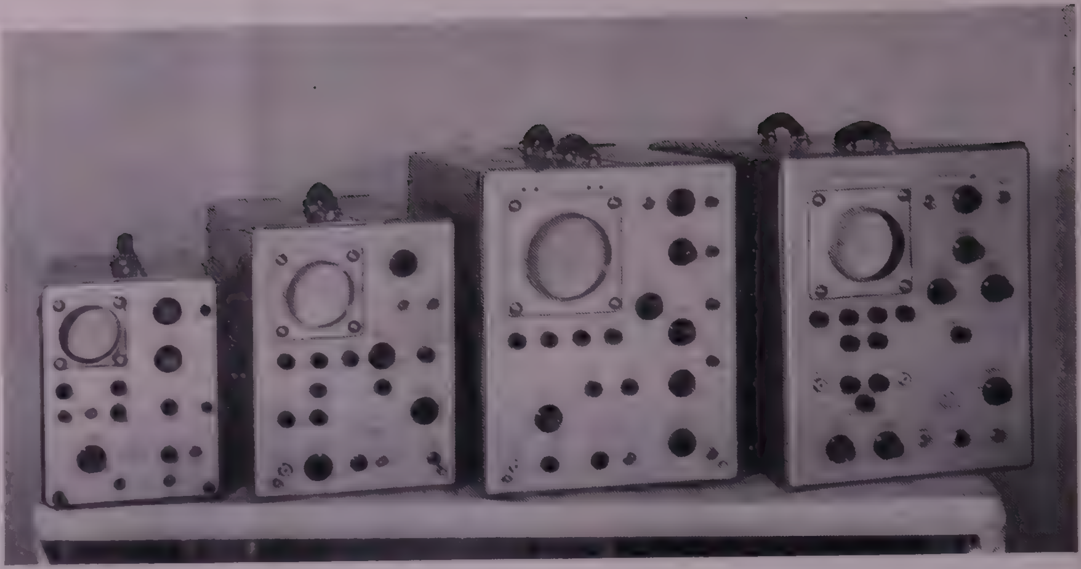
**Friden flexo writer for preparing input on paper tape for INIS, Vienna, and multiple library catalogue cards**



## Oscilloscopes

TILL recently oscilloscopes were being imported into India. Considering the need for a general purpose oscilloscope for developmental activities, R & D work in this direction was taken up in the various institutions in the country. At the Bhabha Atomic Research Centre, Trombay, the Test Equipments and Display Systems Section initiated R & D work for making triggered oscilloscopes in 1963-64. As a result of this effort, two models were produced: one with a bandwidth of DC-3 MHz, with a 50 MHz EHT supply, largely using indigenous components, and the other with DC-10 MHz bandwidth employing RF EHT supply, and using imported components of proven stability and performance. The performance of these models was evaluated by the Chief Inspectorate of Electronics, Ministry of Defence, Bangalore in December 1964. The Division subsequently suplied 150 oscilloscopes meeting the special climatic and environmental requirements of the Defence Services. Among these special requirements is their ability to perform within the specified accuracy in the temperature range of –25°C to +55°C at RH of 95 per cent and above, and also under the desert conditions of high temperature and extremely low humidity.



**Oscilloscopes from 3 MHz to 10 MHz, single and dual trace.**

During 1965-70, besides handling the needs of the Defence Services, the Centre undertook development work on test equipments for oscilloscope production and calibration, as also on instrumentation for industrial and medical use. The Centre has so far developed 5 models of oscilloscopes: around 328 oscilloscopes have been fabricated by it, of which over 200 have been supplied to outside institutions.

### Instruments Developed in Recent Years

**Test Equipments**

A range of different types of oscilloscopes, Dual Trace Adapter, Pulse Generators (single, double and triple pulse generators), Time Mark Generators (for testing and calibration of various electronic instruments required in the developmental projects), Transistor Curve Tracer (TCT), and Transistor Curve Tracer Adaptor (for converting a CRO into a TCT), ECG Simulator (for calibration of Electro-Cardiographic equipment) etc.

**Display Systems**

X-Y-Z display (for Scinti Camera display), X-Y plotter (for indigenous multi-channel analyzer), 5 channel counting set-up (for cable break-down studies under KV operation at the Victoria Jubilee Technical Institute, Bombay), Pulse Discharge Counter (for special instrument transformer testing) etc.

**Industrial Instrumentation**

Spontaneous Motor Activity Display (for pharmacological studies of drug reactions), Constant Current Generator (for calibration of Power Station meters), R.F. Millivoltmeter (for measuring R.F. signal strength in the overhead KV transmission lines for Tata Thermal Station), Paging System (for Anushaktinagar Hospital) etc.

**Medical Instrumentation**

Medical instrumentation work can be divided into various categories depending upon the end use:

* Electromyograph (EMG) and Stimulators for Clinical and Diagnostic evaluation in Neuromuscular disorders,

* Muscle Activity Monitor and Action Potential Counter for Physical Medicine,

* Muscle Strength Monitor and Read-out, and Muscle Action Read-out for Bio-feedback and Physiological research,

* Cardiac Parameter Display and Eye Velocity Measuring System for Physiological Parameter studies,

* KEM Monitor and Reflex Response Counter for Locomotion studies and Industrial Medicine etc.

## *Low Frequency Measuring System for Analysis in the Audible Spectrum*

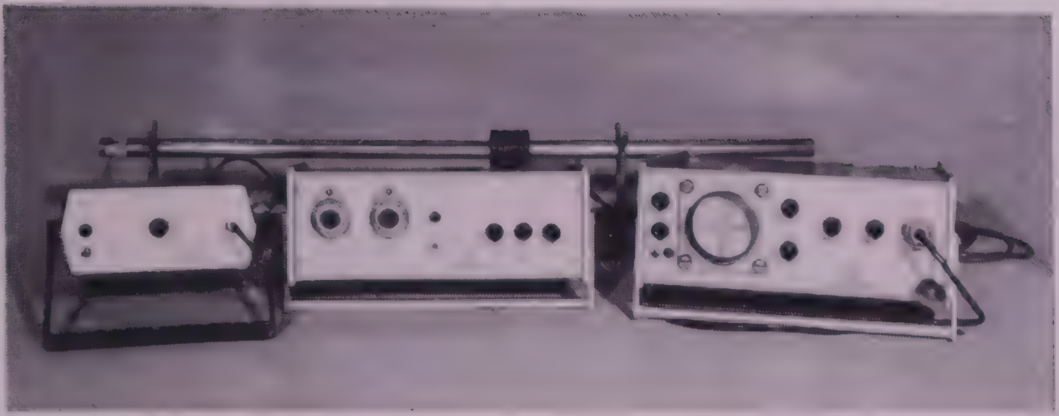
NUCLEAR power stations and research reactors employ system controls which are an integrated system of electronic, electrical, mechanical, pneumatic and pressure control devices. The presence of a high level of undesirable noise, vibration etc. is therefore unavoidable in such sophisticated control systems. It is a well known fact that noise causes annoyance which further causes irritation and discomfort, physical fatigue and consequently poor overall efficiency of the workers. Psychological experiments have confirmed that noise signals in the frequency range of 2 KHz and above are much more annoying and destructive than those in the lower frequency range, though having the same sound pressure level. It was therefore considered essential that the noise present in various atomic power projects be analysed to ascertain its frequency spectrum and to measure the sound level at its constituent frequencies.

In 1973, development work was initiated on a system to analyse noise signals. The low frequency analysis system has been basically designed to analyse the frequency components of a complex wave form in the frequency range of 50-20,000 Hz. It comprises a Third Octave Filter Set (employing 30 narrow band active filters), Wave Analyser, Direct Reading Phase-meter and Digital Counter. A Musical Note Analyser for Spontaneous Display of Fundamental and its 3 Harmonies has also been developed to supplement the system for low frequency analysis, in order to enable analysis of " middle C" note for the National Centre for the Performing Arts (NCPA), Bombay. Analysis of " middle C " note on violin was carried out during Aug-Sept., 1976 at the NCPA.

The system has been extensively tested and measurements and analysis of noise generated in various nuclear power stations is being planned in conjunction with the Power Projects Engineering Division of the Department of Atomic Energy.

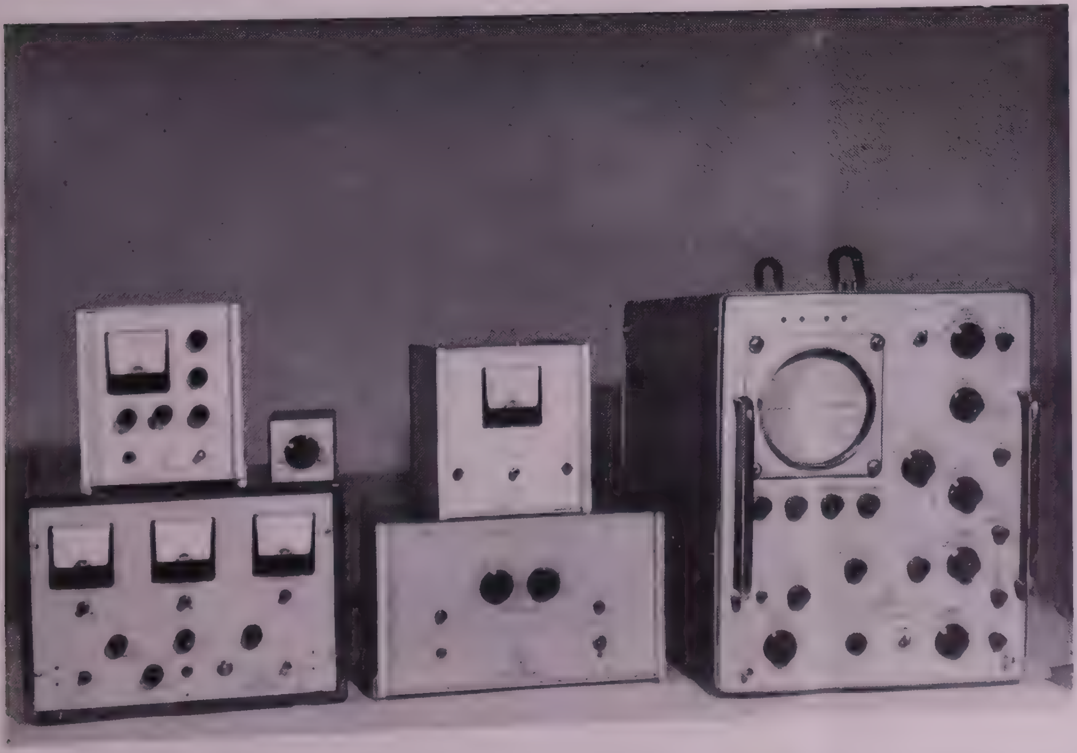
## Non-Destructive Testing (NDT) Systems

THE industrial revolution brought on the need for the selection of different metals and alloys in various shapes and forms for specific uses.

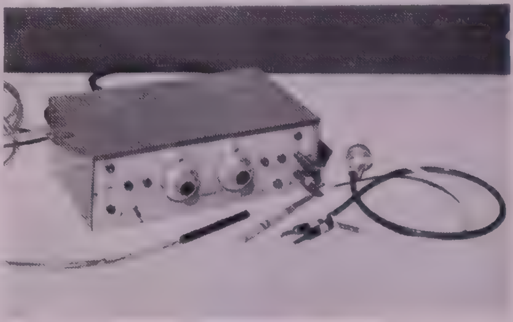

Non-Destructive Testing System

The ever increasing demand for reliable material to meet extremely stringent specifications, especially in the aircraft, nuclear, space, power and other modern industries has given birth to advanced techniques not only in the processing and manufacturing methods and in quality control systems, but also in material testing techniques.

It is well known that a great deal of effort, time, material and money is involved in the planning, construction and operation of a nuclear power installation. Any accident due to leaks, structural failure, fuel element failure etc. could result in hazardous contamination by fission products of the radioactive material which can get distributed in the reactor and the associated coolant system. In such cases, decontamination has to be carried out—a costly time-consuming activity. Failures due to material defects have to be therefore made almost impossible in any nuclear installation.


Low frequency analysis system for analysis of noise pollution and audio spectrum.

There are various methods by which non-destructive testing (NDT) of the material can be carried out. Recent years have witnessed considerable progress in the development and application of eddy current as an NDT tool. A great advantage of this NDT technique is that it can be used for automatic "on-line" inspection of large volumes of materials with greater ease and speeds than is possible through other methods.


Sub Surfla Bridge for enhancing the sensitivity of Magnaflux NDT systems

The BARC has developed an NDT system employing amplitude analysis utilising the eddy current principle. It comprises an X-Y CRT display, Signal Processor, Phase Compensator, Flaw Signal Evaluator compatible to the bobbin type, and encircling type probes developed by the Atomic Fuels Division of the Centre.

Another instrument, named Sub Surfla Bridge, has also been developed for enhancing the flaw detection capabilities of the imported eddy current Magnaflux system in the Atomic Fuels Division.

(*Continued on page 10*)

# *Largest Nuclear Information Centre in South East Asia*

(*Continued from page 7*)

The Library has some 95,000 books and bound volumes of periodicals, and receives 1,700 periodicals in the nuclear and allied fields in English, French, German, Italian, Japanese, Russian and some other European languages; thousands of reprints, patents, standards, and specifications, and about 4,50,000 scientific and technical reports from various atomic energy organisations. Over 50 per cent of the reports are in microform, mainly microfiche. There is a plan to computerise the entire holdings, storing the bibliographic details and descriptors in the computer memory. Already, some 40,000 reports have been computerised.

The Library & Information Services consists of a Technical Information Unit, Bibliography Unit, Publications Unit, Translation Unit, INIS Unit, Computer Unit, Reprographics Unit, Micrographics Unit, Printing Unit and a Photography Unit.

The Technical Information Unit handles scientific and technical queries in nuclear science and technology and also brings out two bulletins : the *Current Awareness Service on Reactors, and Nuclear and Neutron Physics*—a monthly publication giving bibliographic data on papers published in about 100 core journals received in the Library, and the *Nuclear Information Bulletin*—a quarterly bulletin highlighting various BARC projects, giving information about other nuclear organisations of the world, seminars, symposia, etc.

The Bibliography Unit has compiled over 50 bibliographies on subjects such as uranium enrichment, heavy water production, peaceful nuclear explosions etc. On an average, 130 to 150 reports and, 10 to 12 proceedings of symposia sponsored by DAE and BARC are brought out by the Publications Unit annually. So far, over 1,500 reports have been brought out.

Over 50 per cent of the technical and scientific literature of the world is published in languages other than English. In the areas of nuclear science and technology, about 60 per cent of this literature is available in English. To make available non-English literature to the scientists, a Translation Unit was started in 1954. The Unit has been translating papers, reports, etc. from French, German, Italian, Russian, Spanish and some other European languages, and Japanese. More than 8,000 scientific and technical papers and other publications have been translated to-date. A list giving their bibliographic details is being now computerised. The Unit has been conducting courses in French and German since 1968, and some 1,200 BARC scientists have attended these courses so far. A quarterly bulletin is published giving details of the translations done. This information is also sent to 'Transatom' of the Commission of European Communities, for publication in their monthly bulletin.

As computers are being increasingly used in information work, a Computer Unit was set up in 1970 for progressive computerisation of information handling and library routines.

A Selective Dissemination of Information (SDI) service was started in May 1972, covering technical reports. At present, there are 75 profiles.

Currently, computerisation of all the publications of the Centre (exceeding 10,000), over 8,000 translations done so far by the Translation Unit, the entire Library holding of 95,000 books

(*Continued on page 12*)

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# *Some New Electronic Equipment from BARC*

(*Continued from page 9*)

Thin wall monel tubes for the Madras Atomic Power Project, having wall thickness of 2 mm, can be inspected for flaws—scratches of the order of '3 thou' deep, on Magnaflux when used along with Sub Surfla Bridge.

Both the systems have recently been used for the *in situ* detection of leakage in the moderator coolant tubes at Unit I of the Rajasthan Atomic Power Project and are now being employed by the Atomic Fuels Division for inspection of nuclear grade material produced by the Nuclear Fuel Complex, Hyderabad.

In view of the great demand of NDT systems for the nuclear programme it is planned to develop (a) a Multifrequency NDT System to cover a wide range of ferrous and non-ferrous material in a variety of shapes and sizes, (b) Multiparameter NDT System for detection of flaws in heat exchanger tubes in the presence of structural elements and heavy support material and (c) Deposition Thickness Measuring System both for the 'metal on metals' as well as 'non-metal on metal' depositions.

## Automatic Warning System

THIS joint project of the Research, Design and Standards Organisation, Ministry of Railways, Lucknow, and the Electronics Division, BARC for the development of "Automatic Warning Systems" (AWS) for the Indian Railways was taken up in November 1971.

The Automatic Warning System has been developed to augment the existing vigilance system in the locomotive, and is designed to give distinctly different audio as well as visual warning to the loco crew of the signal aspect the train is approaching. The system design provides for take-over of the train controls in case the red signal warning is ignored by the loco crew. The system, in that event, brings the train to a dead halt before it reaches the red signal.

The system is fail-safe and has been tested under simulated conditions for speeds beyond 200 km/h, and power supply fluctuations of –40 per cent to +35 per cent of the nominal loco supply.

Three such systems, along with complete technical know-how transfer documentation, have been supplied, under the joint project, to the Research, Design and Standards Organisation of the Ministry of Railways. ●

# The Indian Viewpoint at Shiraz

(*Continued from page 3*)

energy has been successfully applied for power production, in say a couple of decades from now, India will not have to look abroad for its experts but will find them ready at home", Dr. Iyengar said this was the goal of every developing country with a nuclear programme.

DR. M. R. SRINIVASAN traced the evolution of India's nuclear power programme and the thinking behind the choice of the reactors. India started with the enriched uranium fuelled light water cooled, boiling water reactors at Tarapur and moved to PHW reactors at Rajasthan, Madras and Narora which use natural uranium as fuel and heavy water as coolant and moderator.

The Tarapur Station was constructed by an American company on a turnkey basis. However, India participated actively in its construction to acquire competance and experience. India retained the responsibility of site selection, preparation of tenders and contract documents, supervision at the site etc. With the Rajasthan Atomic Power Station, Indian participation grew larger, with India taking the responsibility for project management, construction and installation activities at the site for Unit I of the Station. For Unit II it was greater, with a significant number of special components, including nuclear components, being fabricated in the country. With the third atomic power station at Kalpakkam near Madras, India progressed to complete responsibility for engineering design and manufacture of equipment. A number of novel design concepts were also adopted in the case of the third station.

Besides describing the varied experience gained in the construction and operation of nuclear power plants, Dr. Srinivasan spoke of the efforts made in building up nuclear technology and the industrial capacity to design and fabricate complex components such as calandria tubes, coolant channels, end-shields, fuelling machines and other such special components. The Power Projects Engineering Division of the Department, of which he is the Director, has organised the building up of such a technological base with its extensive quality control and inspection groups which follow up manufacture in different shops in the country. Touching on planning in this area for the very near future, he stated that it was proposed to standardise on the 235 MW reactors and to construct more units of the same size while working at the same time on a 500 MW reactor design which would be available in the late 1980s. Standardisation of the design, he explained, would control equipment costs and minimise construction and installation time, thereby containing the impact of interest during construction. India's experience with power plants of small sizes, he said, indicated that cost per kilowatt installed of nuclear power stations under construction is lower than costs currently reported for reactors in the range of 1,000—1,300 MW under construction in some other parts of the world. Indeed, the fact that all engineering and manufacture of components is done in India has resulted in containing inflationary costs to a minimum. India, he added, had established the capability for design and manufacture of both the nuclear steam supply system and the balance of plant on the conventional side, as well as the capability for supplying nuclear fuel, control and instrumentation equipment.

SHRI A. S. RAO, Managing Director of the ECIL, in his paper, spoke of the infrastructure built-up in the area of electronics in India which has made it capable of self-reliant innovation. He explained that considerable sophistication existed in the product range covered, and in the ability to develop such products indigenously.

Tracing the development of electronics in India, he observed that it had proceeded with emphasis in three major areas: defence, communications and atomic energy. The dominant roles in each of these areas have been played by public sector undertakings wholly owned by the Government of India.

Touching on the experience of the public sector electronics industry in the country, Shri Rao observed that while foreign technology could at best enable a company to quickly establish production of new items, fast growth of the enterprise can only be achieved through its own technological innovation. Dependence on a foreign technology would keep an enterprise in a passive state where everything is done on instructions and as per set procedures.

On ECIL's experience particularly, he said the practice of giving responsibility to every scientist who sought it, and allowing him to fulfill this responsibility in his own free way was continued at ECIL. The process of transferring know-how from BARC, a basically R & D institution, to ECIL, a commercial venture, brought out many lessons and points relating to the most favourable conditions required on both sides—the givers and the receivers. One of them is that technology transfer is most effective where the development gap as well as the organisational cultural gap is small. This has been the case with ECIL and BARC. There was a like-minded innovative culture on both sides and the teething troubles through which ECIL had to pass had already been passed through by BARC. Drawing on this experience, Shri Rao concluded that technology transfer could be smoother and more effective from one developing country to another, than from one developed country to a developing country.

The industrially advanced countries with their societies and cultures attuned to intensive use of technology can be bewildered and frustrated in trying to transplant their technology into a developing country which usually has an abundance of untrained manpower for whom employment has to be found in a hurry. In contrast, technological assistance from one developing country

(*Continued on page 12*)

# *Regional Cooperation on Basis of European Model Urged for Protection of Environment*

(*Continued from page 11*)

to another is likely to be more easily absorbed as the aiding country would be in a position to understand the problems of development in the aided country since its own memory of a similar phase of development is likely to be fresh. Similarly, a technologist from a developing country may be more ready for innovational changes to suit local conditions. In the case of equipment also, there may be occasions when engineering designs from a country like India may be more suited to another developing country, such as say Iran, than those from Europe or North America. By far the most important advantage may pertain to the level of automation; the process from a developing country may be more suited where the need to find more employment for as many people as possible is great. To achieve technological development in a big way a developing country has to depend on its own ability and resources, he emphasised.

THE R & D work and operational experience in the development of a viable technology for radioactive waste management was discussed by Messrs. K. T. Thomas and A. A. Khan of the BARC. Taking environmental considerations first, Messrs. Thomas and Khan were of the view that maximum permissible discharge values should be set to suit the particular environment concerned. In some cases very stringent limits have to be set for release of radioactivity. Giving the Rajasthan Atomic Power Station near Kota city (on the bank of the Chambal River Dam Lake) as an instance, they observed that it was considered not sufficient to base the discharge limits on the consideration of the point of discharge of effluents, capacity of the lake, and the volume of cooling water available. To avoid the possibility of accumulation of certain specific radioactive nuclides in the lake, they suggested that the limits for the release of activity in the effluents should be arrived at by ignoring the dilution effect provided by cooling water. Recognition of such environmental factors they said would lead to the adoption of even more stringent methods to contain radioactivity.

Referring to siting considerations, the authors disclosed that studies had shown that even in coastal locations, with better dilution possibilities because of the sea, radioactivity could accumulate on the shore-line due to various factors.

The authors drew a distinction between developed and developing countries in the matter of the discharge of radioactivity from nuclear plants. While in developing countries, hazards to the population around the nuclear plants could be present due to its sustenance on the produce of the sea, rivers or agriculture in and around, in developed countries, a better transportation system and exchange of products of various regions provided for what they termed as a 'dilution effect.' Other considerations are the larger intake and utilisation of water in the developing countries in the warmer climates, and the overall average poor health standards prevailing among them.

Of regional cooperation in this field, the authors observed that similarities in the level of development as well as in the available resources made mutual sharing of capabilities possible. Regional bases for attacking the problem of pollution in the initial stage of development of nuclear technology would be of immense value for all countries in the region. The Nuclear Energy Agency of the OECD in Europe which oversees waste management practices of the member countries, they observed, is a system of this nature.

The authors suggested long-term planning for protection of the environment from radioactive releases on a regional basis, and urged regional cooperation in research and development in the field of radioactive waste management, particulraly in the studies of dispersion mechanisms and modes of reconcentration of radioactive nuclides and their return pathways to man.

Shri K. Nanjundeswaran, Superintendent, Technical Services, of the Tarapur Atomic Power Station spoke of India's experience in the engineering, construction and management of atomic power stations, with particular reference to the Tarapur Atomic Power Station. ●

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# *BARC's Library and Information Services*

(*Continued from page 10*)

and bound volumes, and 4,50,000 reports, is on hand. Using these data bases, library routines such as issue, reminders, control of periodicals etc. will be computerised progressively.

The Library and Information Services provides short-term training in library routines, computer handling of information, indexing, operation of reprographic and micrographic equipment etc. to personnel from various institutions and organisations in the country.

The future plans of the L&IS include participation in the National Information System for Science and Technology (NISSAT) planned by the Department of Science and Technology, Government of India. Under the NISSAT plan, the BARC's Library & Information Services will be the national centre for dissemination of nuclear information. Computerisation and SDI service will also be further extended to cover other types of literature, such as periodical articles, conference papers etc. Using INIS tapes, a national SDI service is also planned. ●

## NOTICE

To cover a large number of readers, *Nuclear India* is being sent to major public libraries, university libraries and Government of India Information Centres. Interested readers are urged to contact these centres as we are not in a position to enroll names of individuals on its mailing list. *Nuclear India* is also not available on subscription.

Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India,
Chhatrapati Shivaji Maharaj Marg, Bombay 400 039, and printed by him at G. Claridge & Co. Ltd., Bombay 400 001.

**Registered No. R. N. 9002/62**

NUCLEAR INDIA

VOL. 15 No. 11 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY JULY 1977

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### A New National Research Facility

# The BARC Cyclotron Is Operational

THE Variable Energy Cyclotron (VEC), fabricated and assembled at Calcutta by the scientists and engineers of the Bhabha Atomic Research Centre (BARC), Trombay became operational in the early hours of June 16th. The VEC is among the advanced sector-focussed AVF accelerators now operating in the world, and one of the most sophisticated research facilities in India. Its successful commissioning marks a significant achievement for the country in that the project was executed entirely with indigenous effort, without the participation of any foreign individual.

**by Dr. A. P. Thatte**
Bhabha Atomic Research Centre

**Technical Features**

The biggest part of the VEC is its giant H-shaped magnet, weighing 262 tonnes and giving an average magnetic field of 17.1 kilogauss over an area of 224 cms diameter. The assembled steel core of the magnet is 6.1m long, 2.24m wide and 2.9m high. The magnet consumes a maximum of 490 kilowatts of electrical power in its water-cooled main coils, and 460 kilowatts in the trim-valley coils, which are also water cooled. The maximum power of the RF oscillator of the cyclotron is 300 kilowatts — much more than that of the most powerful radio station broadcasting in India. This oscillator, built by BARC, is tunable in the range of 5.6 to 16.5 MHz. The total volume of the resonance system, which operates in high vacuum of the order of $10^{-6}$ torr, is about 23 cubic metres.

The VEC follows the basic design of two similar machines in operation in the USA at the Lawrence Berkeley Laboratory in Berkeley, California and at the Texas A & M University in College Station, Texas. It is designed to accelerate protons upto 60 MeV, deuterons upto 65 MeV and alpha particles upto 130 MeV. Plans are also afoot to develop heavy-ion sources to accelerate other nuclei with energies corresponding to 130 $Q^2/A$ MeV.

An unichannel-15 (PDP 15 + PDP 11) on-line computer is already operating in the laboratory; another, a large 1,000 kilobites IRIS-80 system is being procured.

**Applications**

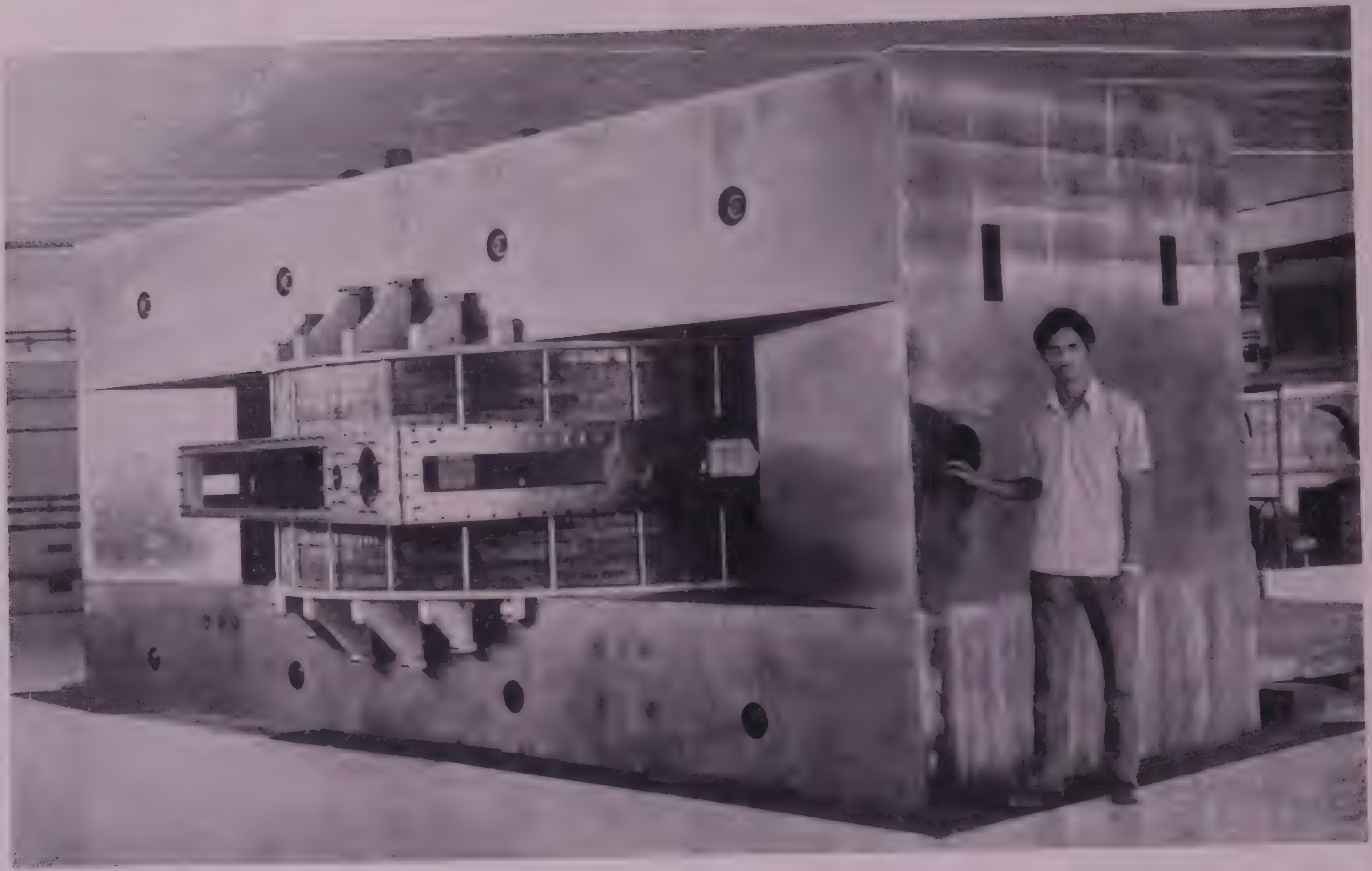
The cyclotron will be used for applications in pure and applied sciences. Besides R & D work in nuclear physics, solid state physics, radiation chemistry and biology, it will be used for radiation damage studies for applications in power and fast reactor technology, for cancer therapy and allied research, and for production of charged particle-induced radioisotopes for use in medicine and agriculture. When fully organised, the cyclotron laboratory at Calcutta will offer an outstanding research facility in South-east Asia. A large number of scientists, including students in universities, national laboratories and research institutions from all over India are already preparing for work at the facility. ●

## The Moment of Success

To obtain an accelerated beam of charged particles from a cyclotron, a number of sub-systems, like the low conductivity cooling water system, vacuum system, health physics monitoring units, closed circuit TV system, air-conditioning system, around 20 different power supply units, and a complex remote control arrangement, have to be operated simultaneously.

Due to severe power shortage, the VEC team kept to all-night work schedules. After a couple of near-successful attempts on two earlier nights, its efforts at last bore fruit on the night of June 15-16, when the magnetic fields were set corresponding to the RF of 8.0014 MHz and a resonance was obtained. The presence of a circulating beam of $\alpha$-particles was confirmed shortly thereafter, using the shadowing technique with the three moving probes. A stack of five 1-mil thick copper foils, mounted on the target probe, was then exposed inside the dee-chamber for a period of 20 minutes to the $4He^{++}$ internal beam at a radius of 40 cm, corresponding to a beam energy of 8 MeV. Around 6 a.m. of June 16, the successful on-set of a $^{65}Cu(\alpha,n)\,^{68}Ga \xrightarrow{\beta+} {}^{68}Zn^{*} \xrightarrow{\gamma} {}^{68}Zn$ nuclear reaction due to an accelerated $\alpha$-beam was confirmed by a neutron monitor placed outside the cyclotron. About 25 minutes after the irradiation was over, the spectrum of $\gamma$-rays from the activated foil was studied using a 75 mm scintillator integral assembly and a 1 k multi-channel analyser. It showed the 0.511 MeV peak due to positron annihilation and also the 1.08 MeV $\gamma$-peak from the first excited state of the daughter $^{68}Zn^{*}$

# Industry Meets VEC's Demand of Skill an



**Main magnet of the Variable Energy Cyclotron installed by BARC.**

A NOTEWORTHY feature of the Rs. nine-crore VEC project is the participation of many leading industrial establishments in the country in its construction.

Over a dozen public and private sector establishments such as the Heavy Engineering Corporation, Ranchi; the Bharat Heavy Electricals Ltd., Bhopal; the Garden Reach Workshops, Calcutta; the Electronics Corporation of India Ltd., Hyderabad; the Indian Telephone Industries Ltd., Bangalore; the Variety Engineers, Baroda; the Tata Institute of Fundamental Research, Bombay; the NGEF Ltd., Bangalore; Brentford Ltd. and Blue Star Ltd., Calcutta; Messrs. Crompton Engineering, Madras as well as Larsen and Toubro Ltd., and Chowgule Engineers Ltd. of Bombay, specially fabricated a variety of equipment for the cyclotron, with technical assistance from BARC.

## Many Firsts

Because of the complexity of fabrication, most of these organisations invested a high degree of skills as well as modern techniques and machine tools for the first time. Production of low-carbon, low-porosity steel castings (with controlled impurities), weighing over 50 tonnes; vacuum tight welding of 50 mm thick low-carbon steel and stainless steel plates, identical contour machining, within 125 microns, of 45 mm thick steel forgings, weighing over 200 kgs. each, were attempted for the first time in the country at the Heavy Engineering Corporation. The Bharat Heavy Electricals specially developed jigs and moulds to undertake the job of water-tight, low resistance joining of 28.5 mm square hollow copper conductor lengths, insulating them with samica-therm tapes, and forming and epoxy potting them into odd-shaped coils, to stringent accuracies in dimensions. The Garden Reach Workshops of Calcutta had to solve many problems in achieving high-vacuum-tight quality welding of 40 mm thick copper-clad and boiler quality steel plates for fabricating the super-size (3.13 m long × 2.36 m wide × 2.39 m high) resonator tank. The challenging job of fabricating huge stainless steel and non-magnetic alloy structures, and water-cooled corrugated copper skins, (also within a few micron accuracies), for the dee, dee-stem assemblies was taken up by the BARC workshops at Trombay with special jigs. Parts of the giant oil-diffusion pumps, freon refrigerated chevron baffles and pneumatic gate valves were fabricated by Variety Engineers and BARC. High capacity air-cooled transformers were custom-made by Brentfords, while large size pumps in aluminium bronze, for circulating low

# apability

conductivity cooling water in all-copper systems were obtained specially from Crompton Engineering. Radiation resistant electronic and television equipment was supplied by the Electronics Corporation of India Ltd. BARC, on its part, developed powerful plasma torch equipment to cut 2.4 m diameter holes in the centre of 45 mm thick, 3 metre square stainless steel plates. A number of highly regulated electric power supply units, using latest solid-state and integrated circuitry for currents upto 2,000 amps. D.C. were also successfully made at BARC for the first time.

### Valuable Scientific Culture

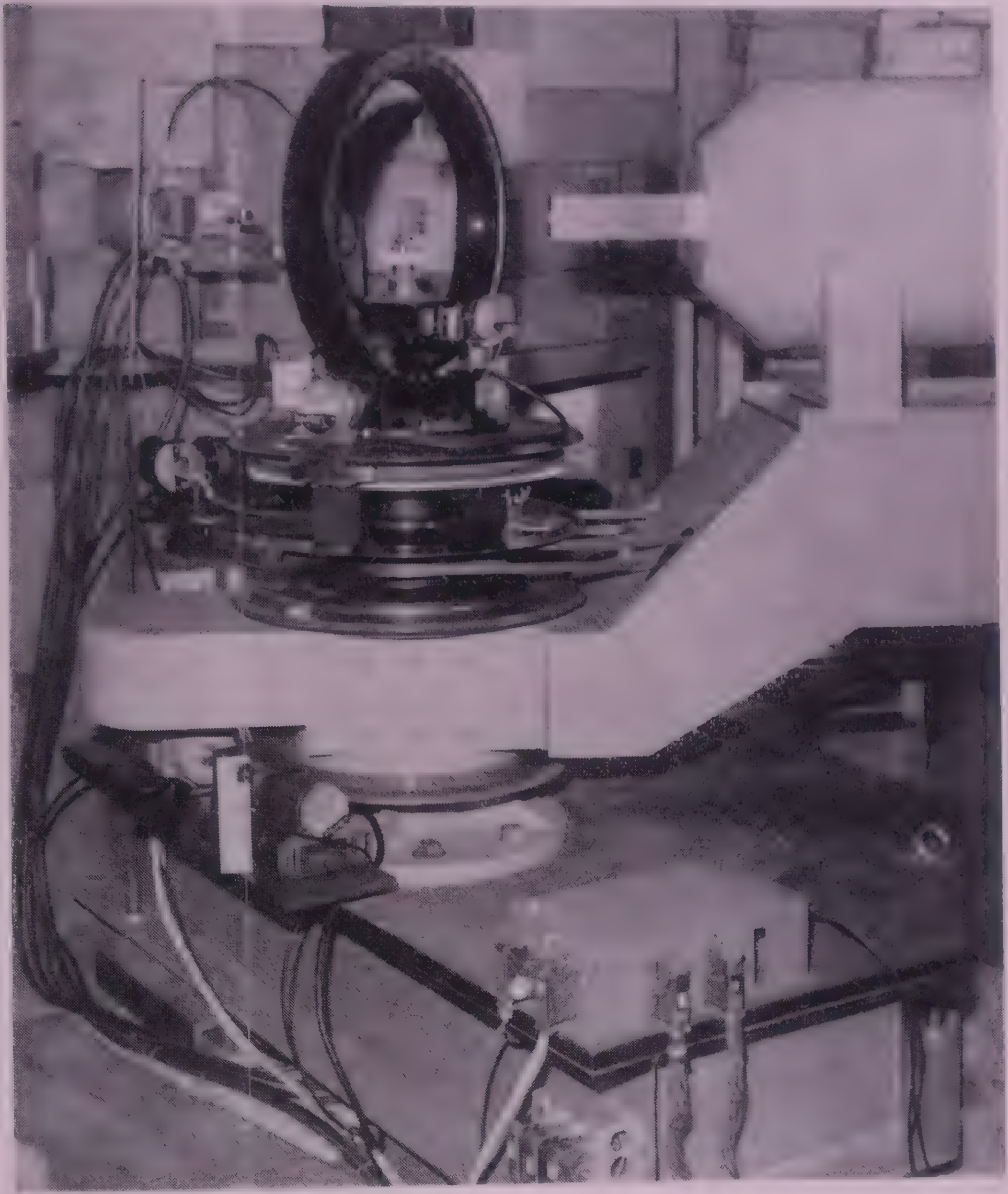
At many of these organisations, the artisans involved in the actual machining and fabrication work had never before been required to attempt meeting such exacting specifications, nor did they ever have any exposure to modern accelerator technology practiced in Western developed countries. Considerable effort was therefore put in at all levels in educating and training the personnel involved.

### New Developments

The VEC project has also given an impetus to development in India for front-line activities in many areas. Magnet technology, cryogenics, large-size high vacuum systems, on-line process control, computer software for nuclear research, sensitive methods for material analysis, remote control and monitoring of complex systems operating in high radioactive environments and latest modular printed board integrated electronic circuitry are a few of them.

The complexity of the task of building a modern nuclear particle accelerator like the VEC can be gauged from the fact that scientists and engineers of BARC specialising in diverse disciplines like nuclear physics, technical physics, mechanical, electrical, electronic and civil engineering, metallurgy, vacuum technology, chemistry, health physics, desalination and effluent engineering, public health, etc. have been working on it for many years. ●

# Computer-Controlled Neutron Diffractometer at BARC



**The diffractometer located at the CIRUS beam-port. A TDC-312 computer system is attached to the unit**

AN on-line computer-controlled 4-circle neutron diffractometer designed and fabricated by the Neutron Physics Section of the Bhabha Atomic Research Centre has been commissioned at the CIRUS reactor at Trombay. Interfaced to an ECIL TDC-312 (4K) computer system, this is the first on-line controlled (X-ray or neutron) diffractometer to be developed in the country. The high fabrication standards of the diffractometer have ensured positioning accuracies of better than one hundredth of a degree on each of its four angles. With sophisticated application software, involving over 40 user-oriented teletype commands, the system can be operated with ease, even by an experimenter unfamiliar with the computer or the programmes.

The system has been operating very satisfactorily for over an year and is expected to help in neutron diffraction studies of the structure of complex molecules. Based on the experience gained from the development of this system, the Neutron Physics Section is now working on a computer-controlled X-ray diffractometer system, in collaboration with the Electronics Corporation of India Ltd. ●

## *Progress Report*

# Atomic Ene

THE Department of Atomic Energy has been making concerted efforts at indigenisation by developing know-how and encouraging Indian industry to acquire the competence and capacity to meet the demands of the nuclear programme. In 1976-77, these efforts moved the country further in this direction with units such as the Bhabha Atomic Research Centre, the Power Projects Engineering Division, the Nuclear Fuel Complex and the Atomic Minerals Division reporting important developments in nuclear techniques and technology in their particular areas. Some of the highlights of work during the year are given here.

Major reactor components such as the reactor vessel (calandria), fuelling machine heads, nuclear fuel components etc. are already being manufactured in India. During 1976-77, some more components such as the fuelling machine carriage, and shielding and sealing plug assemblies for reactor II of the Rajasthan Atomic Power Station, were added to the growing list of nuclear items fabricated in the country. The fuelling machine carriage is of considerable size but with dimensional tolerances comparable to those of wrist watch components. It involves fabrication of heavy structures employing the latest techniques in welding, stress relieving of large structures, heat treatment of various alloy steel components, and precision machining. The coolant channel shielding plug and sealing plug assemblies involve multi-discipline techniques, and advanced technologies such as stainless steel nitriding. The latter process was used for the first time in the country.

### *Novel Technique*

A noteworthy achievement in nuclear mineral prospecting in recent years is a novel prospecting technique evolved by the Bhabha Atomic Research Centre and the Atomic Minerals Division. This technique is extremely simple and reliable in the exploration of uranium. Known as the BARC-TEFUREX, the technique is an instance of basic research yielding practical applications. The technique is expected to play an important role in the Department's atomic minerals exploration programme.

Another interesting piece of work at BARC is in the field of opto-electronics. Development work on an image intensifier tube — a device used in passive night vision, is in its last stages; a cascade of three such image intensifiers is expected to achieve light amplification of the order of 50,000, necessary to see even under overcast star-lit environment.

Desalination is another area of interest at BARC where work is in progress on a 30 tonne/day shipborne desalination plant. A one tonne/day pilot desalination plant, designed and fabricated by the centre has been operated for sometime for demonstration to prospective users.

### *MHD Programme*

Another important development at Trombay is a high temperature argon plasma jet unit which has been set up there recently. The unit will help in studies related to the magnetohydrodynamics (MHD) programme, particularly on MHD plasmas and materials being developed at BARC for MHD power generation. The plasma unit can also be used for evaluating high temperature material required in the steel, cement and thermal power industry.

The MHD complex, incidentally, is being set up at Tiruchirapalli jointly with Bharat Heavy Electricals Ltd.

A 100 MW thermal reactor project termed R-5 is making good progress at Trombay. The reactor building super structure upto the ground floor level is almost ready, while major components of the reactor are being fabricated.

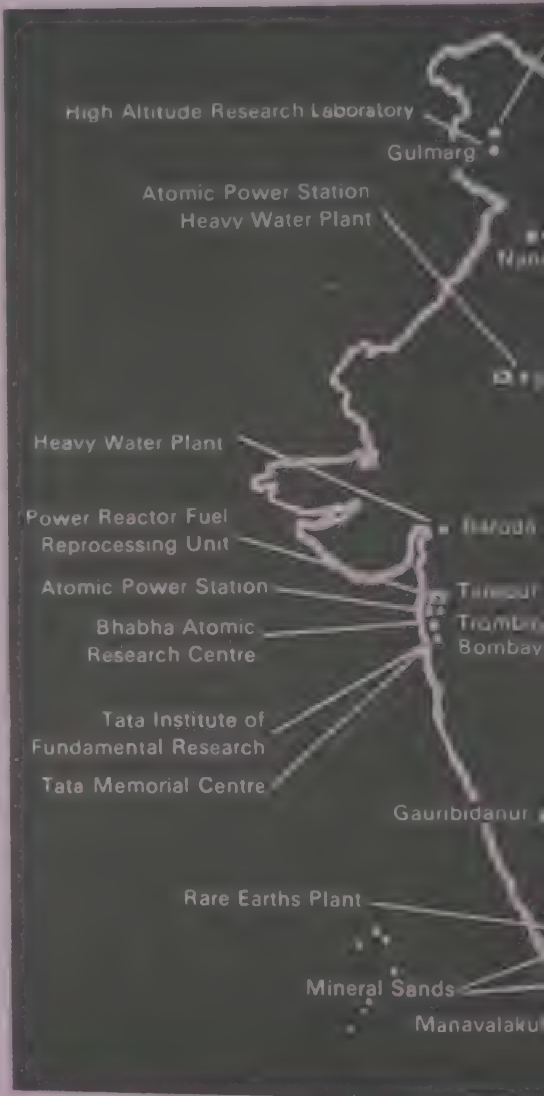
The Variable Energy Cyclotron built by the BARC at Calcutta has become operational.

The Fast Breeder Test Reactor (FBTR) which is under construction at the Reactor Research Centre (RRC) at Kalpakkam is entering an important phase, with the fabrication work in hand on various critical components, in different workshops in the country. Besides the FBTR, work has also started at RRC on a 500 MW prototype fast breeder reactor.

### *Nuclear Power*

During the first 11 months of the year, the Tarapur Atomic Power Station generated 2013 million Kwh compared to 1903 million Kwh for the corresponding period in 1975-76 — an increase of approximately 11 per cent. The Station registered a capacity factor of 60 per cent till end February 1977 which compares favourably with other nuclear power stations of similar design elsewhere in the world.

The total output from the Rajasthan Atomic Power Station-I during the period April 1976-February 1977 was 970 million units. The total energy gene-



# y : 1976-77

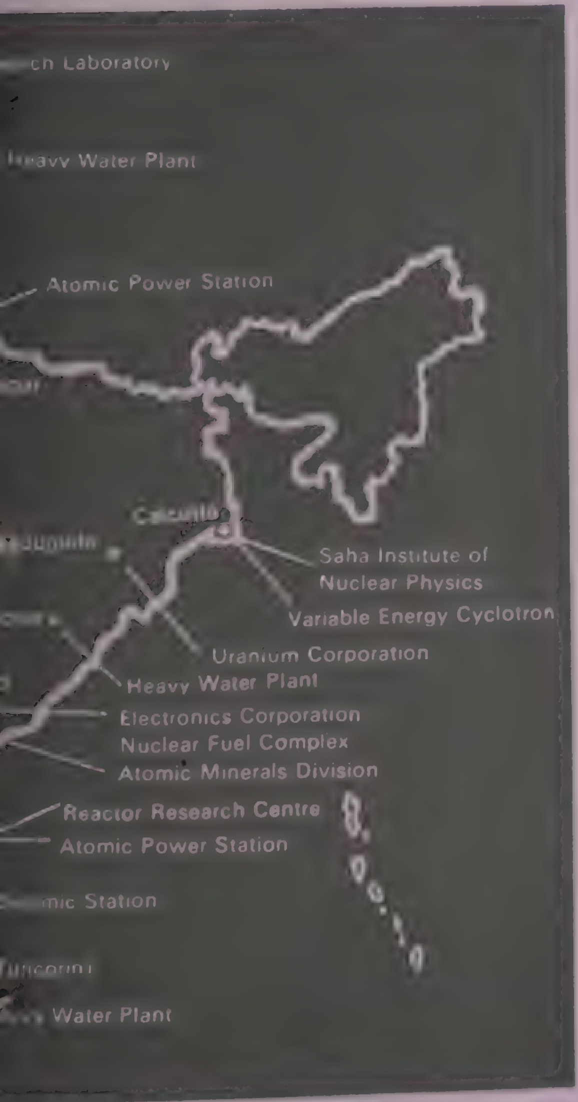
ration in 1976-77 is expected to be about 1,080 million units.

The second unit of the Station is in an advanced stage of commissioning.

At Unit-I of the Madras Atomic Power Station, major items of equipment, both nuclear and conventional, have been installed while fabrication of equipment is on for Unit-II. At the fourth nuclear power station, at Narora, main plant civil works are on and design work on the nuclear and conventional systems is in progress. Fabrication of nuclear equipment and the turbo generator has also been taken up.

## *Radiological Protection*

The countrywide personnel monitoring service for evaluating radiation exposures covered nearly 42,000 radiation workers from 2,280 institutions. The corresponding figures for the previous year are 38,000 and 2,106 respectively. Countrywide radiological protection surveys were conducted in 165 institutions, consisting of 115 medical, 28 industrial and 22 research institutions.



During the year, the Advisory Group of the Division of Radiological Protection processed 421 plans connected with X-ray and teletherapy installations, industrial radiography units and radioisotope laboratories; 55 radiation installations were approved for final construction. Advice on the use of radiation sources, equipment and associated safety aspects were given in 1,464 cases and 1,623 applications for procurement of radioisotopes from potential users were processed.

## *Seismology*

A high degree of self-reliance has been achieved with respect to seismic array instrumentation and processing facilities. The experience in array technology is now being applied to seismic investigation of rock-bursts in deep hard-rock mines. A Rs 17 lakh project has been undertaken for the Bharat Gold Mines Ltd., Kolar, to locate the foci of rock-bursts down to low levels, with a network of 6 seismographs located at ground level so as to surround the mine workings susceptible to strata failure and using computer-based iterative source location techniques.

## *Training*

One hundred and fifty-three graduates in science and engineering of the 19th Course of the Training School trained for one year from August 1975 to July 1976 were absorbed in the various divisions of the BARC and other units of DAE. Besides, twenty-two engineering graduates selected for training in reactor operations and maintenance were given on-the-job training in the Reactor Operations Division for another six months. 209 young graduates in science and engineering are presently undergoing training in the 20th course of the BARC Training School which commenced in August 1976.

## *Biology & Agriculture*

Trombay groundnut strains (TG) again showed superior yields in Gujarat and Saurashtra where they were grown by local cultivators for seed multiplication. The Indian Oil and Produce Exporters Association (IOPEA) has sponsored an extensive seed multiplication programme for these groundnut cultivators. The seed multiplication and distribution programme is being managed by the Vanaspati Manufacturers' Association of India. The performance of the TG strains was also extremely good at the cultivators' fields in Maharashtra and in other states where they were tested.

Trombay rice cultures were tested at Vadgaon in Maharashtra by the Mahatma Phule Krishi Vidyapeeth. TR-18 and 17 yielded respectively 7002 and 6676 kg/ha which were significantly higher yields compared to 4810 kg/ha of the variety Sona. These and other cultures were also tested in the fields of several progressive farmers in Maharashtra and the results were found encouraging.

## *Nuclear Fuel Complex, Hyderabad*

For the first time production of coolant tubes for the Madras Atomic Power Station (MAPP-I) was taken up at the Complex.

The Complex also made an important contribution to the import-substitution drive of the Department by successfully fabricating Rectangular Section Wire in zirconium-niobium-copper ternary alloy needed to meet the requirements of garter springs for units I and II of the Madras Atomic Power Project.

The Special Materials Plant of the Complex made a break-through in the world market by exporting a consign-

*(Continued on page 6)*

## *Radioisotopes, Vasectomy Kits ....*

Ready-to-use sterile vasectomy kits developed by ISOMED, the plant at Trombay for radiation sterilisation of medical products, are in such great demand that efforts are being made to interest industry to take up large-scale production of the kits. ISOMED has thus demonstrated how the radiation sterilisation process can help surgery in camps and primary health centres in far-flung areas in the country where facilities for sterilisation of surgical equipment are not readily available. 50,000 vasectomy kits produced by ISOMED on a trial basis were supplied to family welfare departments in several states.

One of the most significant achievements of the R & D effort in this area has been the development of a radioimmunoassy kit for the assay of Human Placental Lactogen (HPL). This assay enables early detection of complications in pregnancy.

Another useful radioisotopic device is a compact isotopic X-ray unit using iodine-125 which has been designed for low energy radiography of teeth, bones etc. The possibility of using other indigenously available low energy isotope sources in place of the imported iodine-125 source is being considered.

The number of radioisotope users in the country rose to 765 from 650 last year. The total value of equipment and radioisotopes sold and services rendered during the year was Rs. 75 lakhs, as against Rs. 68 lakhs last year. The export component of the sale was approximately Rs. 4 lakhs, compared to Rs. 2 lakhs the previous year.

## *Progress Report*

(*Continued from page 5*)

ment of 150 kg. of ultra-high purity indium metal to West Germany. The purity achieved is of the order of 99.999 per cent. This order has brought foreign exchange of Rs. 3.50 lakhs.

### *Public Undertakings*

During 1975-76, the Indian Rare Earths Ltd. earned a net profit of Rs. 97.3 lakhs after providing Rs. 26 lakhs for depreciation, Rs. 5 lakhs for gratuity and Rs. 147.6 lakhs towards taxation. The Company paid a dividend of Rs. 17.02 lakhs.

The Company also diversified its export marketing base as a result of which it was possible for it to establish itself in the markets for ilmenite in the USA and Taiwan.

During 1975-76, the Electronics Corporation of India Ltd. earned a net profit of Rs. 61.86 lakhs after providing for depreciation of Rs. 180.38 lakhs, interest of Rs. 229.67 lakhs on loans and borrowings, expenditure on social facilities of Rs. 38.44 lakhs and income tax of Rs. 112 lakhs. Besides transferring an amount of Rs. 0.85 lakhs to the Development Rebate Reserve, an amount of Rs. 61 lakhs was transferred to the General Reserve. ●

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## Man and Environment

(*Continued from page 8*)

met by clearing forest areas, resulting, in the process, in many inter-linked adverse effects on the environments, including soil erosion, landslides, flash floods and depletion of ground water resources. Deforestation has deprived wild life of its natural habitats and contributed to the depletion or extinction of many rare species.

### Man and Biosphere

The idea of Biosphere Reserves is based on the concept of preservation of life in its totality so that it may serve as a natural referal system for the future and serve as a bench-mark. This enables preservation of total genetic diversity. This genetic diversity of plants and animals in a biosphere reserve is a great resource for mankind if properly looked after. Among the wild vegetations, there may be wild rice or wild fruits and cereals which can be cross-bred to give new varieties which may be more resistant to diseases, or give higher yields etc. Animals can provide a resource for experiments for medical and physiologic research; research in this area has become more important to understand man himself. These species of wild animals are very important for study.

While considerable stress is laid on prohibiting the killing of wild animals, hardly anything appreciable has been attempted, so far, to preserve wild plants or a proper total environment for plants and animals.

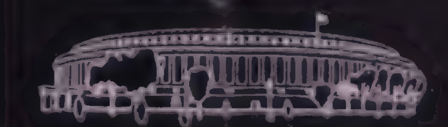
### *Conservation of Natural Resources*

With a view to evolving and promoting national policies relating to environmental preservation, the Government of India had constituted the National Committee on Environmental Planning and Co-ordination (NCEPC). Some of its terms of reference are : Identification and proposing solutions for problems of human environment; reviewing policies and programmes having a bearing on the quality of environment; advising government departments, public authorities and industries on environmental matters; promoting environmental research, public awareness and cooperating with the U.N. and other international agencies on action to safeguard human environment. Quite a few research projects in environmental preservation and biosphere studies have been identified and funded by NCEPC.

Much of the success in environmental preservation in advanced nations is due to intervention by enlightened citizen action groups.

In many countries, school and college students have also contributed significantly by taking up many tasks of environmental preservation—from hygiene and planting of trees to taking care of gardens and national parks in the countryside. Before a studied action for environmental improvement can be initiated, society's understanding of the intimate relationship between quality of the environment and human well-being has to be clearly understood. Environmental education has an important role to play in this direction. (*PIB.*) ●

# Answers in Parliament



### Nuclear Power Production

During the year 1976-77, 3252 million Kwh of energy was generated through the use of atomic energy.

The energy requirements of the country are met by a mix of thermal, hydro and nuclear power plants in which the role of nuclear power is marginal. The situation created by the oil crisis will have to be met by increased reliance on coal-based thermal power. According to present plans, an installed capacity of 6000 MW, subject to availability of finance, is tentatively envisaged for nuclear power stations by 1990.

Of the existing operating power stations *viz.* Tarapur Atomic Power Station and Rajasthan Atomic Power Station-I, only Tarapur Atomic Power Station requires enriched uranium obtained from USA. The Rajasthan Atomic Power Station does not require nuclear material from foreign sources. Delay in obtaining enriched uranium is likely to handicap future operations of the Tarapur Atomic Power Station.

(*Lok Sabha*, 15*th June*, 1977)

### More Nuclear Power Stations

The Site Selection Committee appointed by Government for selecting suitable sites for location of an atomic power station in the Eastern Region has, in its report, recommended some sites in the States of Gujarat and Maharashtra.

There is at present no gap between the generation of power and the demand in Gujarat.

The report submitted by the Site Selection Committee is under active consideration of Government.

(*Lok Sabha*, 15*th June*, 1977)

The Committee appointed by Government for the selection of suitable sites for the setting up of nuclear power stations has examined a number of sites in the Southern Electricity Region, of which Andhra Pradesh forms a part. The Committee's report is under consideration of Government.

(*Lok Sabha*, 22*nd June*, 1977)

The Site Selection Committee appointed by the Department of Atomic Energy has considered the proposal made by the Government of Maharashtra for the expansion of the Tarapur Atomic Power Station along with other sites suggested by the Governments of Maharashtra and Gujarat for the location of an atomic power station in the Western Region.

(*Lok Sabha*, 29*th June*, 1977)

## Dr. Sigvard Eklund Re-appointed as IAEA Director General

The Board of Governors of the International Atomic Energy Agency (IAEA) at Vienna has unanimously appointed the present Director General, Dr. Sigvard Eklund, for another term of four years, starting 1 December 1977.

This appointment, in accordance with the Statute, is subject to approval by the General Conference of the IAEA which will meet on 26 September 1977 for its twenty-first regular session.

Dr. Sigvard Eklund was first appointed Director General of the IAEA in 1961 for a term of four years and unanimously reappointed in 1965, 1969 and in 1973.

### Reactor Research Centre, Kalpakkam

The Reactor Research Centre, incorporating the Fast Breeder Test Reactor and associated research facilities under construction at Kalpakkam, Tamil Nadu is planned for research and development of technology for the establishment of fast breeder reactor nuclear power stations.

The Fast Breeder Test Reactor is under construction.

(*Lok Sabha*, 22*nd June*, 1977)

### Radioactivity

Air borne radioactivity is being monitored in the country for the past several years.

Routine measurement of radioactivity in air is being carried out through a network of monitoring stations located at Gulmarg, Gangtok, New Delhi, Calcutta, Bombay, Nagpur, Bangalore, Hyderabad, Ootacamund, Madras and Thumba. Radioactivity in the environment resulting from nuclear operations is being monitored by a chain of environmental monitoring laboratories located at Bombay, Tarapur, Rana Pratap Sagar (Kota), Kalpakkam, Hyderabad, Jaduguda, Alwaye.

The levels of total atmospheric radioactivity have been found to be in the range of 0.1 - 0.5 dpm/cubic meter of air, which is the normal level to be expected from natural sources. The levels of environmental radioactivity have also been found to be well within permissible limits prescribed by the International Commission on Radiation Protection for the members of the public from time to time.

The measurements so far done have revealed that the levels of radioactivity are within permissible limits and not injurious to human beings.

(*Lok Sabha*, 15*th June*, 1977)

## India on IAEA Governors' Board

India is one of the 12 countries which have been designated as members of the Board of Governors of the International Atomic Energy Agency (IAEA) for the year 1977-78.

The 11 other countries are Australia, Brazil, Canada, Egypt, Federal Republic of Germany, France, Italy, Japan, United Kingdom, United States and USSR.

The decision was taken at the 501st meeting of the IAEA's Board of Governors held at Geneva recently.

# Man and Environment

OF nature man is part, neither separate nor independent. He is, however, unique in his influence over nature. Man derives the wherewithal of life from nature; but, if he does not take care to protect it, he will soon find that he has put his own life and that of unborn generations in danger of extinction.

It is truly said that in all countries, big or small, developed or developing, progress has become synonymous with an attack on nature. Man's progress and prosperity must be achieved without alienating man from his heritage and without destroying nature of its beauty, freshness and purity that are essential for a healthy, contented life.

## *Pollution*

The air, water, soil, plants and trees—insects, animals all constitute the environment. These interact on each other and maintain a proper balance, called "ecological balance". Man, in the process of development causes certain changes in his environment. If these changes disturb the harmony in nature and the ecological balance, he runs the risk of not only increasing the cost of development but also the imbalances that instead of enriching his life might seriously affect his living conditions. This imbalance creates pollution.

If populations are small, the effect on the environment is proportionately less, provided other conditions remain the same. In developing countries like India, where development has put a severe strain on the environment, the increase of population also adds to this environmental strain, because the basic needs of food, energy, water, clothing and shelter of all people have to be satisfied. On the contrary, in advanced countries, where the population is small they are in a position to make liberal use of the earth's resources, and also the resources of other less developed countries in order to sustain their affluent styles of life.

## *Sources of Pollution*

The sources of pollution are: (i) Human settlements, (ii) Agro-industrial operations, and (iii) Power Generation.

### Human Settlements

We live in aggregation that vary from a small village to a large metropolitan city. These settlements, irrespective of their size, have to be so organised that their needs, such as, housing, food, education, employment, health care and transportation are fully catered to. If the organisation is not adequate to the population, or if there is not sufficient care, then, villages can be insanitary and towns and cities can become congested, noisy, disease-ridden, and full of slums. In both cases, the quality of life suffers and man becomes unhappy. It is not only economic constraints that can lead to such situations but also a lack of civic consciousness among the citizens. It has to be realised that factors that make life pleasant and worth living are not only those that are obtained through spending money, but also a proper attitude and way of life. Therefore efforts should be to ensure that human settlements enrich the quality of life for the people.

### Agro-Industrial Operations

Industries are often the big polluter. India, like other industrialised countries too, has its own severe pollution problems. Improper location of industries, use of "polluting" technologies, and inadequate waste treatment facilities are chiefly responsible for deterioration in the quality of air and water in industrialised cities. Other indirect stresses on the environment come from creation of slum colonies of migrant workers from rural areas.

As industrial growth is vital for the nation, industrial development has to be carefully planned to include environmental considerations.

Similarly, multi-purpose projects such as dams and large irrigation projects have an important role to play in the economy of the country. They can also adversely affect the ecology of the region if not properly planned or operated. Areas likely to be submerged could be dense forests, the habitat of wild life. Problems of water-logging could arise. Migration of fish could be adversely affected.

In agriculture, excess fertilisers put into the field naturally get washed away during draining operations or by rain into nearby watercourses, causing uncontrolled growth of aquatic vegetation. If the same thing happens to pesticides applied on the fields, it can lead to toxic effects on aquatic life—effects that may in many ways be transmitted to man himself. Pesticides and weedicides can also poison man through an improper use through fruits and vegetables.

### Power Generation

Energy is needed now in almost all walks of man's life—for cooking food; for producing utensils to cook food, to store water, to produce clothing, or bricks for the houses. While energy is necessary, if not carefully tended, its generation and use can be a polluter of environment. For instance, the mining, processing, transportation, burning of coal and disposal of consequent ash material could each pollute the environment heavily. The use of fuel in motor vehicles leads to exhaust emissions that can foul the air and cause smog. Even the ordinary cowdung cakes when burnt in congested areas can be a serious health hazard due to air pollution. Proper disposal of wastes needs serious R & D efforts.

An environment that threatens the existence of animals and plants is not safe for the human beings either. There is a constant battle for accommodating the growing needs of population. Increased demand for land for agriculture, settlements and other projects is usually

(*Continued on page 6*)

Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India,
Chhatrapati Shivaji Maharaj Marg, Bombay 400 039, and printed by him at G. Claridge & Co. Ltd., Bombay 400 001.

**Registered No. R. N. 9002/62**

NUCLEAR INDIA

VOL. 15 No. 12 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY AUGUST 1977

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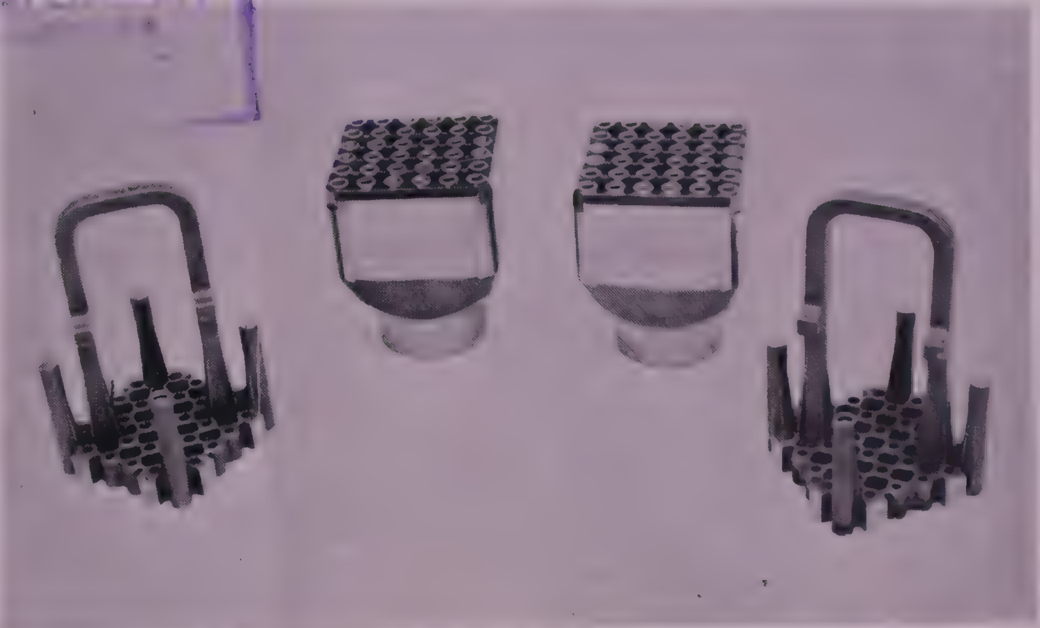
*Tie-plates for Tarapur*

# BARC Efforts Help Build Sophisticated Technology in India

By **G. R. Kamat**
Central Workshops
Bhabha Atomic Research Centre

THE emphasis on self-reliance in the manufacture of nuclear components has helped in establishing at home yet another sophisticated technology—that of preparing precision castings in intricate shapes by lost wax investment casting process. This technology was developed by the Bhabha Atomic Research Centre as part of the effort on the manufacture of tie-plate castings for the reactors of the Tarapur Atomic Power Station. In the absence of indigenous manufacturing capabilities, the castings have been imported so far.



**Precision cast and machined top and bottom tie-plates made at BARC for the reactors of the Tarapur Atomic Power Station.**

The tie-plate castings (upper tie-plate and the lower tie-plate) are used in the fuel bundle assembly made by the Nuclear Fuel Complex, Hyderabad, for the core of the reactors of the Tarapur Station. Made in stainless steel grade $CF_8$, these castings need a very high degree of structural integrity, very close cast dimensional tolerances (about 1 to 5 micron per mm and surface finish of 2-3 microns). Equally complex is the machining aspect of the castings.

### Stringent Requirements

The castings are about 112 × 112 × 150 mm in size, and weigh approx. 2.5 and 3.5 kgs. respectively. The complex geometry, and the stringent requirements of dimensional precision and surface finish preclude the use of the normal casting methods. A few trials conducted at the Central Workshops of BARC helped in establishing that the intricacies of the component can be fully achieved through the investment casting method. The subsequent machining feasibilities of the castings were also ascertained at the Workshop.

It might be mentioned that this casting process is in principle ideally suited for mass production of small, intricate components (weighing a few hundred grammes) to precise dimensions.

### All-India Survey

As the demand for the tie-plate castings is of a recurring nature and as the capital investment for setting up a production facility is heavy, the Central Workshops took up the challenge of gettingt hem made locally. After an all-India survey, it found only one party with the capability to undertake the job with the assistance of the Workshop. The complicated dies needed for making the patterns were also made locally. The firm has commenced production.

To ensure an alternative source of supply, BARC has also encouraged a Bombay firm to undertake production of the castings. With the guidance of BARC at all stages—from die manufacture to mould-making and subsequent casting and machining, the firm has produced castings of an acceptable standard.

About 200 pairs of these castings are used during each refuelling cycle at the Tarapur Atomic Power Station. By encouraging indigenous production, BARC has not only saved a recurring annual foreign exchange expenditure of about Rs 20 lakhs but has also made this sophisticated technology available at home. By making this component, the industry has also built up confidence to undertake precision castings of bigger components in ferrous alloys where the dimensions and shape cannot be achieved by any other process. ●

**Food Irradiation: Contributions to Public Health in Developing Countries, by Dr. K. Sundaram.** *Page 3*

# International Intercomparison of Cerium-139

**by P. K. Srivastava**
Division of Radiological Protection
Bhabha Atomic Research Centre

IN the various applications of atomic energy, especially in the areas of medicine, industry, agriculture and research, an essential pre-requisite is an internationally accepted range of accurate standards of radioactivity. In nuclear studies, fundamental properties like fission-yields, reaction cross-sections and decay-schemes are determined by the absolute measurement of radioactivity, which requires precise standards. In medicine, similarly, primary standards are essential for the use of radioisotopes in diagnosis and therapy at the lowest possible level of exposure to the patient.

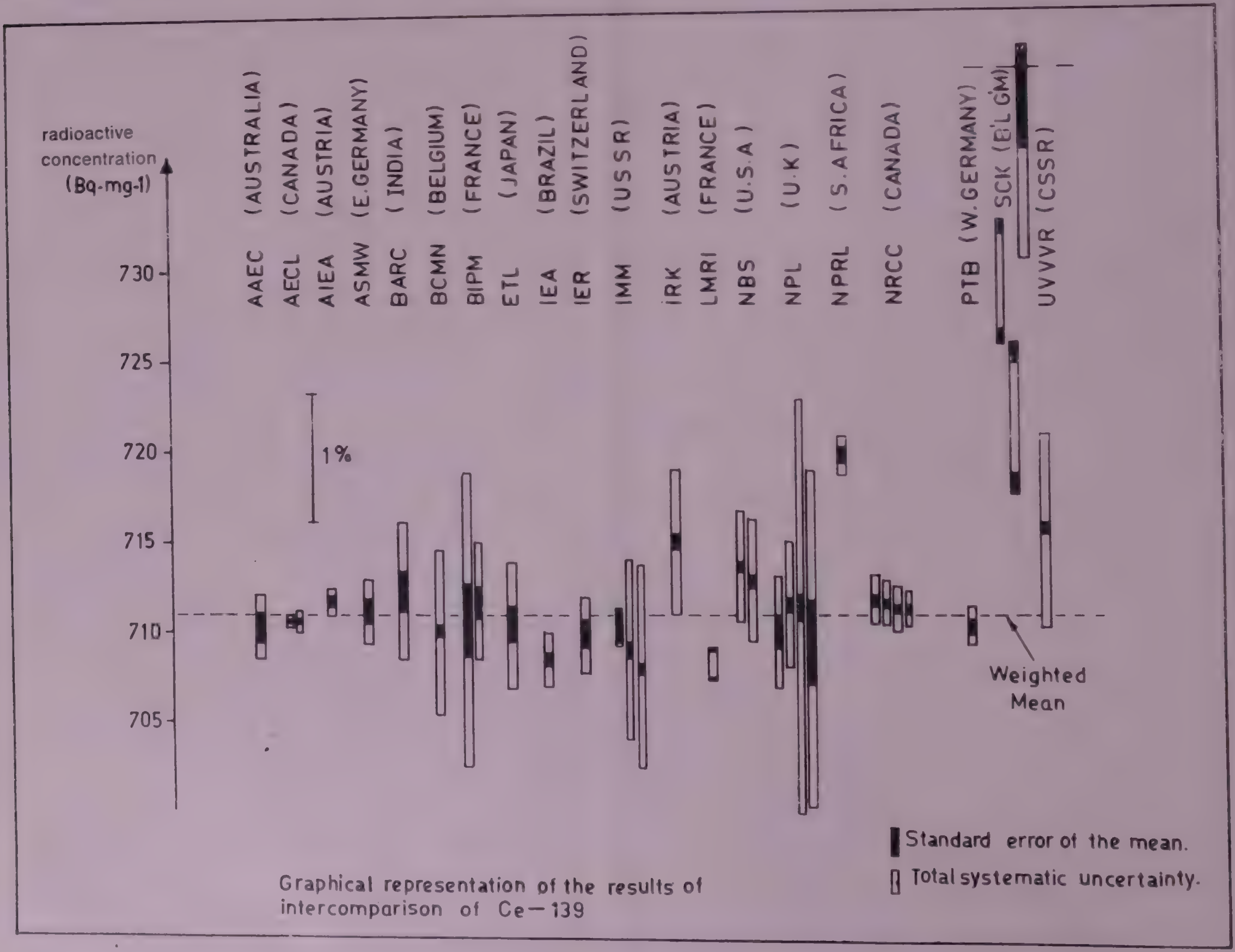
To establish and maintain the wide range and variety of standards of high accuracy and reliability, special techniques have to be developed. In India, work on preparing national standards of radioactivity is done by the Radioactivity Standards Section of the Division of Radiological Protection of the Bhabha Atomic Research Centre, (BARC) Trombay.

National standards established by the different standardizing laboratories of the world are compared at frequent intervals to check the accuracy and reliability of the methods of standardization. For this purpose, a programme of international intercomparison is organised from time to time by the Bureau Internationale des Poids et Mesures, France (BIPM). This is an international effort to improve the accuracy, precision and reliability of standardizing techniques, and to achieve uniformity in the results of measurements carried out in different parts of the world. The results of the intercomparison are compiled and published in detail by the BIPM.

The programme is very useful in determining the agreement between the results of participants, and is also effective in identifying the best procedure for the development and maintenance of standards and methods of standardization.

To achieve these aims, an international intercomparison of Cerium-139 was arranged during May 1976 by the

(*Continued on page 8*)



Graphical representation of the results of intercomparison of Ce−139

# Food Irradiation:

## Contributions to Public Health in Developing Countries

**by Dr. K. Sundaram**
Bio-Medical Group
Bhabha Atomic Research Centre

IN any discussion of food irradiation and its contributions to public health in developing countries, there are a number of factors which have an interaction. Two elements which dominate the analysis are poverty and population. These two factors have consequences which are widely applicable to large population groups in many areas of the world which fall under the term "developing countries". By poverty, I mean, inadequacy among individuals to fully "demand" their needs.

Demographers have a theory of "demographic transition" which suggests that, accompanying technological progress, the rate of natural increase in population of any country passes through three phases. Phase I represents the period when both death rate and birth rate are very high, leading to a slow natural growth of population. In phase II, death rate declines, thus increasing the average life expectancy, but birth rate stays high to very high which results in an acceleration of population growth. In Phase III, birth rate declines dramatically and the rate of natural growth stabilizes at around 1 per cent per annum.

This concept of "demographic transition" seems to have been fulfilled. However this theory does not indicate the rate of change in technological progress or the time scale over which this change must be achieved for these transitions from one phase to another to occur. Most developing countries are in Phase II of this growth curve and the population doubling time seems to be about 25 years. It is therefore relevant that these large population groups have to be provided food, shelter and a quality of life at least to levels of human survival.

Fig. 1: The developing countries of Africa and Asia have the lowest availability of protein and calories. With the recent recognition that human daily requirements of protein may be less than those estimated earlier and the consequent scaling down of these figures by international agencies, total food deficit assumed greater importance. It has been shown that if enough food (calories) is supplied, the protein gap if any, vanishes.

It may be seen that with the advent of the green revolution, the per capita availability of food has shown an increase during the past decade, although population increase during the period has been significant. Currently, the gap between estimated requirement and availability is small and gives the hope that the countries can be self-sufficient in the near future.

The national averages often do not tell the full story as economic factors lead to uneven distribution of total food supplies. The shortages are more severely felt by the poorer segments as they are economically unable to demand their full share; thus, economically weaker sections of most developing nations live in a chronic state of near famine (Fig. 2).

(*Continned on page 4*)

**Fig. 1**

**Global availability of Food Protein and Energy (1971)**

| *Region* | *Available protein g per caput per day* | *Available food energy* | |
|---|---|---|---|
| | | *Cal. per caput per day* | *per cent of requirement* |
| Developing countries .. | 57.4 | 2200 | 95 |
| Africa .. .. .. | 58.4 | 2190 | 94 |
| Far East .. .. | 50.7 | 2080 | 94 |
| Latin America .. .. | 65.0 | 2530 | 105 |
| Near East .. .. .. | 69.3 | 2500 | 102 |
| Developed countries .. | 96.4 | 3150 | 123 |
| World .. .. .. | 69.0 | 2480 | 104 |

**Fig. 2**

**Trends in availability and needs of Food Energy in India**

| | *Food energy per caput per day Cals.* | *Remarks* |
|---|---|---|
| Availability in 1965 .. .. | 1958 | The gap between available resources and estimated needs, on national average basis, is marginal. (around 5-8 per cent) |
| " 1970 .. .. | 1992 | |
| " 1975 .. .. | ~ 2100 | |
| Estimated requirement .. | 2210 | |
| Icmr Recommendation (for adults) .. .. .. | 2400 | |

# Radiation Preservation M

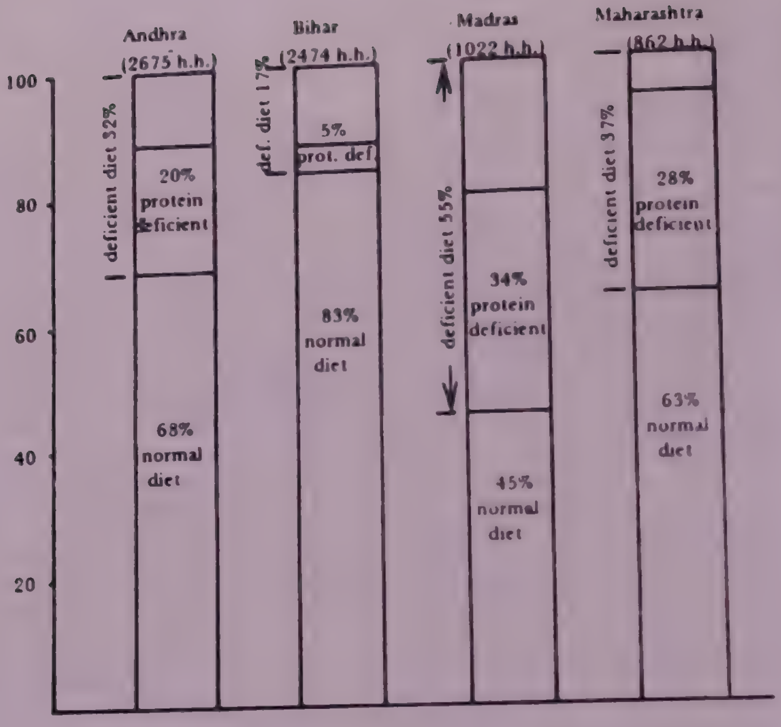


**Fig 3: Protein and calories deficiency of households in four Indian states.**

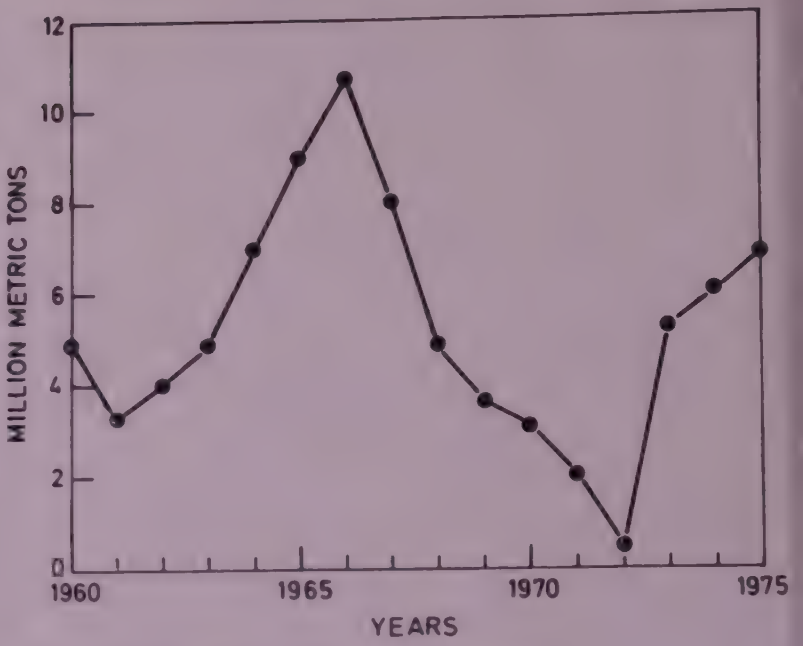


**Fig 4: India: Grain Imports, 1960 to 1975.**

(*Continued on page 3*)

Fig. 3: The existence of calorie and protein deficiencies in several thousand households in four different states of India is shown. These figures clearly bring out the fact that the extent and severity of dietary inadequacies among individuals or families are masked by average food availability figures, especially when economic disparities are rather high in the population. The basic and most important public health problems facing the countries of the developing world, therefore, is a small insufficiency of food resources and an apparently large inadequacy in vulnerable sections of the populations to purchase food.

The food needs of the population have often to be met by developing nations through import from surplus countries.

In the case of India, such imports of food grains have been marginal during the past decade, when reckoned in terms of the country's production. Thus, as against the current production of around 118 million tonnes, the imports have ranged between less than 0.5 to a maximum of around 10.0 million tonnes a decade ago (Fig. 4).

It is an unfortunate paradox that even with this limited availability of food, considerable quantities of the food that is grown are lost as a consequence of adverse climatic conditions and the lack of effective methods of conservation.

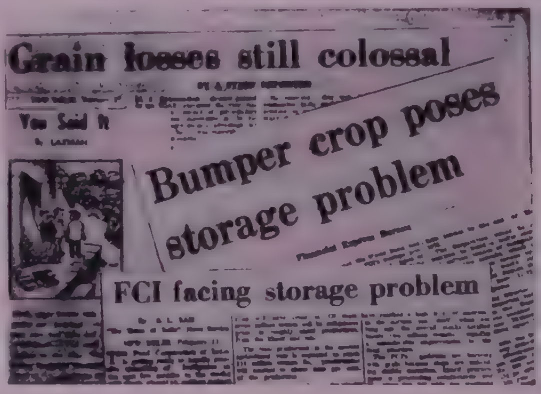
The recent spurt in agricultural production has served to emphasise the inadequacy of the storage facilities. (Fig. 5). Advances in the agricultural sector will have to be geared up to the development of adequate post-harvest technological measures to ensure the accrual of maximum benefits. In India, the loss of cereal grains, the major staple food, during storage, is estimated to be around one tenth of production. The full significance of this loss can be realised by comparing it with the figures of food grain imports shown earlier.

**If the losses can be significantly minimised, even if not totally eliminated, the country could have avoided the import of grains during the past decade, which has been a major drain on our foreign exchange reserves.** To give you a feel for figures, in an effort to hold a buffer stock of food grains, the Government of India spent around 2700 million dollars (over 2400 crores) to buy 18 million tonnes of food grains. The most conservative estimate of losses of food grains have been of the order of 10 per cent of this produce or around 10-11 million tonnes, costing over 2000 million dollars (1800 crores).

From the foregoing, it is amply evident that an easy, short-term, practical step toward bridging the marginal gap between availability of food and the needs of the population would be through effective conservation of all that is produced.

And as a bonus the money saved could be deployed for betterment of living standards of the rural section of the population and towards a positive public health programme.

Although there are extensive well-developed technologies that are successfully employed in the industrialised countries for processing and preservation of foods, there are severe limitations to their 'in toto' transfer to most developing countries. These constraints arise from inadequacy of various national resources like finance, materials, the needed technological infrastructure and, above all, energy. The entire food system in the developed countries is energy-intensive.



Grain losses still colossal

You Said It

Bumper crop poses storage problem

FCI facing storage problem

**Fig 5**

# Offers Valuable Alternative

The food industry in the USA, for example, accounts for over one-eighth of the total energy utilised and, as may be seen from the data, three times as much energy is expanded on post-harvest technology as on production in the farm (Fig. 6).

Looking at it from another angle, over the years of technological development, it has become necessary to put in greater and greater quantities of energy for obtaining a unit amount of food energy. This is primarily because economic considerations of food production and processing in the industrialised countries in the past have been oblivious of energy inputs during the era of abundant and inexpensive fossil fuel availability (Fig. 7).

Such high energy food systems require inputs of energy that are greater by an order of magnitude than those in the less developed countries for providing an equivalent amount of food even at the farm level (Fig. 8).

The developing countries of the world cannot afford to apportion large quantities of their meagre energy resources for food preservation. Additionally, high inputs of energy and the consequential increment in the cost of the produce can only aggravate the imbalance in distribution between different economic segments. These considerations emphasize the need for the adoption of technologies for food preservation that entail minimum energy requirements. It is in this context that developing nations should make an objective assessment of the distinct advantages that radiation preservation offers over other commercial methods. It enables the realisation of the basic objective, *viz.*, extension of shelf-life of various produce in the 'as is' condition, with minimal processing, unlike the majority of other methods.

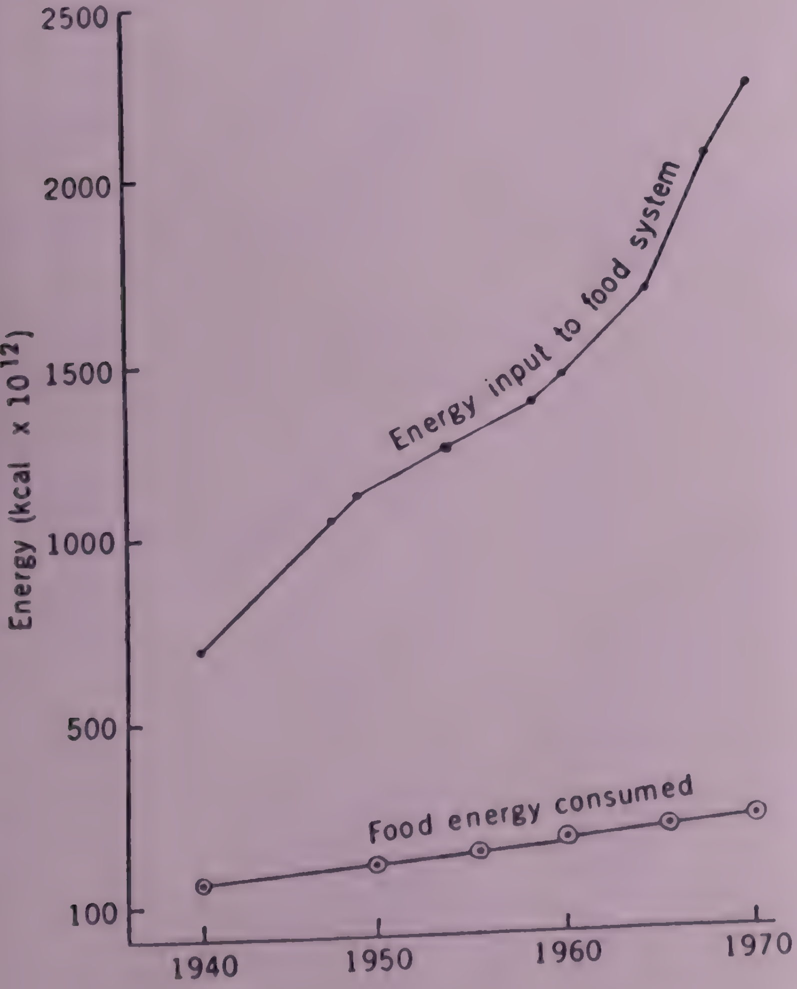
Realising the potentials of the process, the technology has been studied in detail in India for over a decade for specific applications involving major crops of economic and nutritional

(*Continued on page 6*)

**Fig. 6**

**Energy inputs into the Food System in the United States**

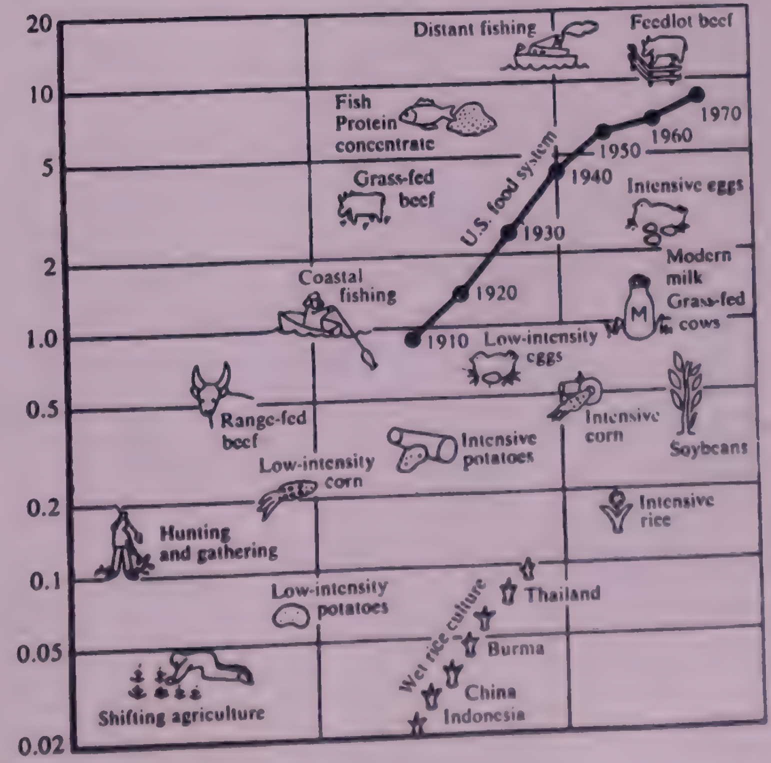
| Phase of food production | Energy expenditure (x 10-12 k cals.) 1960 | 1970 |
|---|---|---|
| on the farm .. .. .. .. .. | 374<br>(26 %) | 526<br>(24 %) |
| Post-harvest technology .. .. .. | 1066<br>(74%) | 1646<br>(76%) |
| Food on the table .. .. .. | 1440<br>(100%) | 2172<br>(100%) |



**←Fig 7 (left): Energy use in food system, 1940 through 1970, conpared to the calorie content of food consumed.**

**Right: Fig 8.**

Calories of energy subsidy for 1 caloric of food output



# Irradiation Extends Sea-Food Shelf-Life

(*Continued from page 5*)

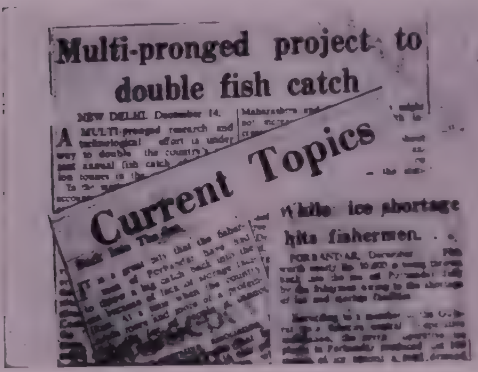
significance to the country. These studies have helped to define processing parameters for disinfestation of wheat, sprout inhibition of potatoes and onions, extension in shelf-life of sea-foods and delaying the ripening of banana and mangoes (Fig. 9).

**Potentials for food irradiation applications in India**

| *Produce* | *Annual output ($x\ 10^6$ tonnes)* | *Economic/Nutritional significance* |
|---|---|---|
| Wheat .. .. .. .. | 25-30 | Major cereal (> 25%); elimination of loss during storage can help quantitative improvement of food availability. |
| Potatoes .. .. .. | 5.0 | Important inexpensive source of energy to bridge the calorie gap. |
| Sea-foods .. .. .. | 1.5 | Only source of animal protein that can be made available on a significant scale; quantitative improvement of food. |
| Mangoes, Bananas .. .. | 6.0 | Minimising spoilage loss will increase availability of these 'protective foods'. Increased export earnings and consequent economic betterment of producers. |
| Onions .. .. .. | 1.5 | Increased export earnings and consequent economic betterment of producers. |

**Fig. 9**

Notwithstanding the recent thinking that provision of enough food (energy) will in itself abolish the deficiency of protein in the diet, the nutritional importance of increasing the animal protein content of diet in the poorer countries is recognised. The only practical source of animal protein that could be tapped to provide significant quantities to vast populations would appear to be the sea-foods. Most developing nations with a coast line are turning their attention to the exploitation of the fishery potential of the seas around them.

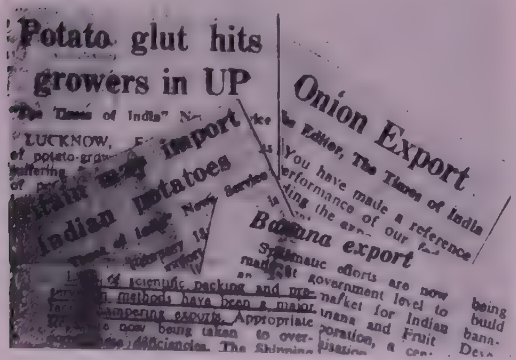

Multi-pronged project to double fish catch

Current Topics

While ice shortage hits fishermen

**Fig. 10**

Fig. 10 brings out the paradoxical situation created by the attempts on the hand to increase catch and the lack of effective preservation methods on the other. A major constraint in expanding fishery operations is that the highly perishable nature of the sea-foods does not permit its transport to markets in the hinterland. Irradiation could provide the critical extension of the shelf-life of sea-foods that is necessary for the purpose, the internal demand created thereby, in turn stimulating increased fishing.


Potato glut hits growers in UP

Onion Export

Indian potatoes

Banana export

**Fig. 11**

The concern for public health, a concern reflected in worldwide assessment of irradiated foodstuff for years, is the prime factor determining acceptance of this process. The large volume of evidence that has been gathered to-date on irradiated foods, both at the national and the international levels is a unique record of nutritional and toxicological assessment of any chemical, let alone a processed food.

It should be reassuring to all that a recently concluded meeting of the WHO/FAO/IAEA expert committee has recommended "unconditional acceptance" of wheat and potatoes and certain additional items for human consumption.

To conclude, let me state that there is a need to capitalize on the opportunities that are already at hand in attempts to solve the problems of food loss. It would be unwise to continue to sit back and watch the insects and the micro-organisms eat the food produced by sweat and toil of thousands of people. We have vast numbers of hungry people waiting for an adequate diet and a better quality of life. Let us not be obsessed by a "perfection in research". After all, we are all imperfect (*IAEA Bulletin, Vol.* 18, *Supplement*) ●

NUCLEAR INDIA

**is a monthly publication of the Department of Atomic Energy, published around the 20th of each month. To ensure prompt attention, all communication should be addressed to the Editor, NUCLEAR INDIA, Department of Atomic Energy, Chhatrapati Shivaji Maharaj Marg, Bombay 400 039. While intimating change of address, the code and number given on the wrapper should be mentioned. Bombay recipients may contact 25 04 77 for prompt action.**

# Science Notes

## *Using the Sun*

SEVERAL projects have been identified in India for utilising solar energy. The programme consists of development of solar thermal energy hardware and systems; development of direct energy conversion devices like photovoltaic solar cells; and establishment of solar energy data collection observatories, data processing and information transfer to solar research scientists.

Under the Solar Thermal Energy Research and Product Development Programme, the priority projects include solar water pumps of 2-5 HP capacity, solar crop driers with a capacity of 1-5 tonnes per day, and solar distillation and desalination equipment for clean drikning water.

The urban and small-scale industrial applications include domestic solar water heaters of 140 and 200 litres capacity, and solar space heating and cooling applications, initially for urban use and for industrial applications in cold storages.

The design and development of collectors for low, medium, and high temperature applications has been taken up as part of a national collector development programme.

For any solar thermal system the basic component is the collector. There are three projects under the collector development programme. One, a major project on space heating, was completed at Hardwar. This facility is now being converted into a testing station for different types of collectors, which can be compared for their performance. Two, in order to develop efficient collectors, it is important to conduct absorption and collection material studies. These studies would involve the fabrication of a test rig and trying out of different absorption and collection material for comparative evaluation of their suitability.

Three, any solar thermal application which requires high temperature would require a concentrator of solar energy. A concentrator collector design has been developed by Punjab Agricultural University, Ludhiana. It is proposed to develop a few collectors based on this design, examine their comparative performance and optimise the design.

## *Domestic Water Heater*

BASED on the success of the experimental data collected from prototypes of the domestic water heater which are currently under test, an engineering re-design of the domestic water heater will be done from the point of view of optimizing its performance and manufacturing cost.

Under the same programme are also the investigations of medium and large scale water heating systems which can be incorporated in guest houses/hotels. A prototype of such a system is under test. Simultaneously, Bharat Heavy Electricals Ltd. is looking into the feasibility of using solar energy for water heating in some of the larger hotels.

Solar thermal energy can be used for cooling purposes by using the principle of vapour absorption. A prototype plant of 1-ton capacity has been developed for refrigeration purposes. Based on the success of this prototype, it is proposed to develop a 10-ton Cold Storage System.

The Birla Institute of Technology and Science, Pilani, has designed a direct-contact vapour pump, a prototype of which has been made and is at present in operation. BHEL is now involved in developing a production-oriented re-design of the pump.

There are at present two technologies developed for converting solar thermal energy into electrical energy. Both these technologies use flat plate non-concentrating collectors. There are other technologies which are more capital-intensive, using tracking type collectors or solar cells.

The project presently undertaken is to develop a 10 kw solar electric power demonstration plant using screw expander and flat-plate, medium-temperature collectors. The ultimate objective is to develop power generation sets for isolated villages not connected by the electrical power grid.

For achieving this objective, an Indo-West German collaboration programme has been initiated. Under this programme, the prime mover and the electrical power generator will be developed as the responsibility of the German collaborator, and the rest will be developed by BHEL of India.

The project consists of two major systems: the first system is an array of about 1000 flat-plate collectors, coupled to a thermal storage reservoir and a circulating pump with necessary flow direction controllers. The solar energy absorbed by collectors is stored in the pressurised reservoir to attain a temperature gradient of between 95°C on top of reservoir to around 85°C at the bottom. The second system consists of an organic fluid to water heat exchanger, organic fluid pump, a screw expander, gearing system, electric generator and electrical energy storage system and controls.

The electrical generating system is to be operated for a period of about 2-3 hours during the day at approximately full load of 10 kw plus the energy required for operating the various pumps installed in the cycle.

Under direct energy conversion devices programme, the main objectives are (i) to conduct research on various types of low cost solar cells ; (ii) to identify the most promising type of solar cell suitable for conversion of solar energy into electrical energy ; (iii) to design and develop systems and undertake field trials ; and (iv) to set up pilot plants for production of low cost solar cell panels.

The Indian Meteorological Department is working on the establishment of several solar data observatories in the country for solar energy data collection, processing and information transfer to research laboratories and solar research scientists. ●

**Corrigendum**

On page 8, Col. 1 of the May-June 1977 issue, an error has been detected in the report on 'Oscilloscopes'. The line "50 MHz EHT supply" should be read as "50 Hz EHT supply". The error is regretted.

## *Radioactivity Standard*

*(Continued from page 2)*

BIPM as part of its continuing programme. Around 20 national and international laboratories participated in this programme.

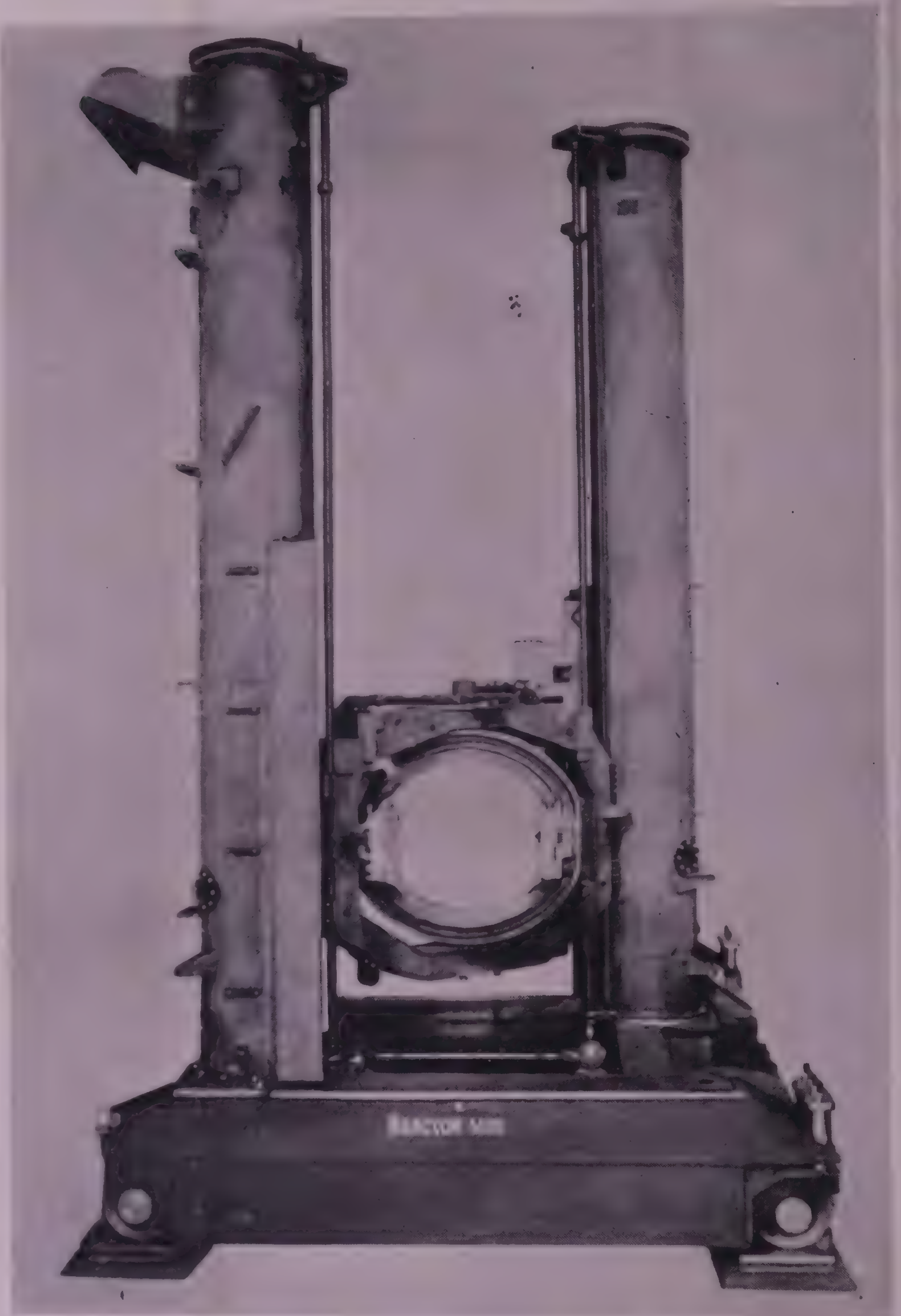
Cerium-139 decays by electron capture. This isotope was chosen because it is used in the calibration of beta-ray and gamma-ray spectrometers, and has a convenient half-life of about 140 days.

For intercomparison, a solution of Cerium-139 in a flame sealed glass ampoule was distributed by the International Atomic Energy Agency, Vienna, to each participant. At the BARC, the $4\pi \times -\gamma$ coincidence counting technique was developed for the absolute standardization of this solution. The method followed included preparation of source samples, from the solution on a micro-balance, counting of these samples on an automatic nuclear counting system, and statistical analysis of the data on the computer BESM-6. The decay-scheme dependent and counting-rate dependent correction factors were applied for every source, and the internal and external consistency of the data was tested for each set. Least squares analysis was used for the calculation of the radioactive concentration of the original solution.

The final result, its systematic and random errors, confidence level and coefficients of Least squares fit and their number of degrees of freedom were sent to the BIPM for intercomparison.

The BIPM has now compiled the results and other details from the 20 participating laboratories in the form of a report. The final result, along with its errors, is reproduced in the figure on page 2. The intercomparison shows that the BARC standard of Cerium-139 is in agreement with those of the leading laboratories of the world within 0.2 per cent, which is of an extremely high order of accuracy. The overall error of the BARC result is also comparable.

## *India-Made Nuclear Station Component*



**Two fuelling machine carriages for the first unit of the Madras Atomic Power Station, Kalpakkam, were delivered to the Department of Atomic Energy last month by M/s. Cooper Engineering Ltd., Chinchwad near Pune. While large weldments were fabricated and machined at Walchandnagar Industries, Walchandnagar, all other components were manufactured by M/s. Cooper Engineering who also assembled the carriages. For the first time, manufacture and assembly of the FM carriages were completed in India by a single agency.**

Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India,
Chhatrapati Shivaji Maharaj Marg, Bombay 400 039, and printed by him at G. Claridge & Co. Ltd., Bombay 400 001.

**Registered No. R. N. 9002/62**

# NUCLEAR INDIA

VOL. 16 No. 1 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY SEPTEMBER 1977

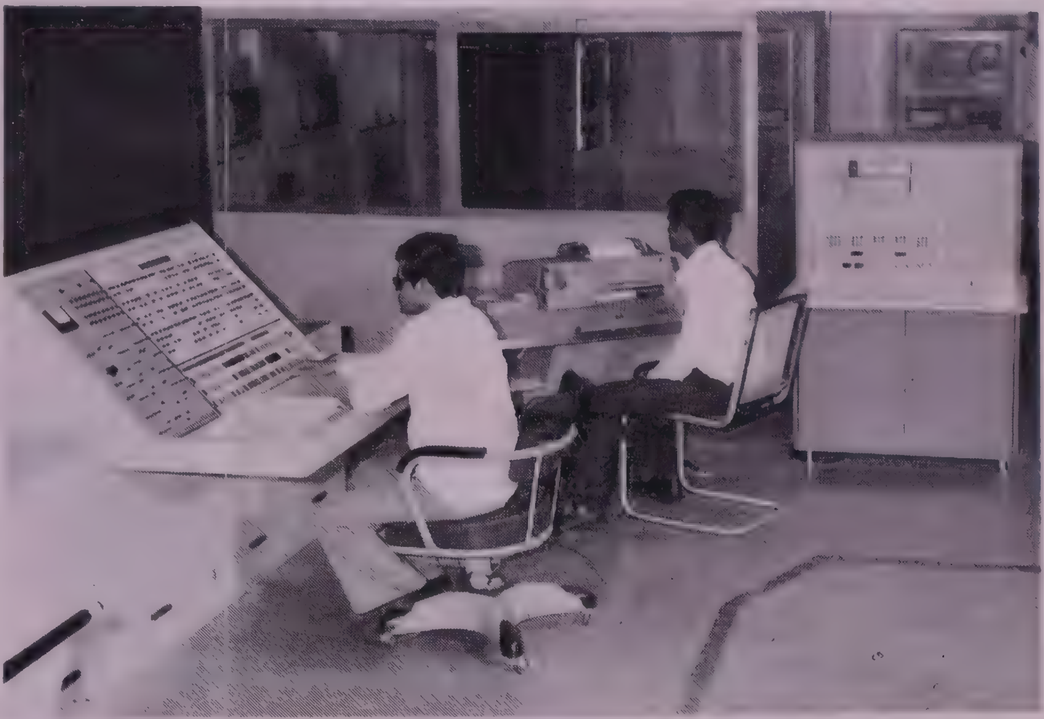
***PHWR Fuelling***

## Computer Based Control System Developed

A COMPUTER-BASED control system for operating fuelling machines of the pressurised heavy water (PHW) type of reactors has been developed at Trombay. This is the first sophisticated computerised control system wholly developed in the country, and marks a major advance towards eventual computer control of a nuclear reactor.

The PHW type of reactors are at the Rajasthan Atomic Power Station and under construction at the Madras Atomic Power Station. The Narora Atomic Power Station will also be having the same type of reactors.

The control system was developed at the Reactor Control Division of the Bhabha Atomic Research Centre in collaboration with the Reactor Engineering Division of the Centre, and the Power Projects Engineering Division of the Department of Atomic Energy.



**At left is the Operator's Console and teletype, and on the right is the computer console. The shaded portion on the panel comprises the simulator which can be used to exercise the computer control system. The entire control system electronics is contained in the inner recess of the Operator's Console. The glass room in background houses the computer electronics and magnetic tape transports**

The control system has been installed and commissioned at the Fuelling Machines Test Facility in the Reactor Engineering Division. It is capable of performing all refuelling operations required to be executed on a reactor channel; it also replaces the hard-wired system currently in use.

**Did the Universe have an Origin?**

**Prof. J. V. Narlikar discusses on page 2**

The PHW reactor comprises an array of fuel channels mounted in a horizontal, cylindrical calandria with each fuel channel containing a series of fuel bundles. In this type of reactor, it is necessary to have continual on-power refuelling to maintain the chain reaction. The refuelling is carried on by two fuelling machines which clamp onto the ends of a fuel channel. The fuelling machines remove the blocking plugs at the corresponding fuel channel ends, then the loading machine pushes fresh fuel bundles into the channel. The spent fuel bundles already in the channel get pushed out into the receiving machine. At the end of the refuelling operation, the machines replace the plugs in the channel and disengage themselves from the respective channel ends. The loading machine proceeds to pick more new fuel, and the receiving machine to disgorge the spent fuel.

At present the fuelling machines have an automatic control system implemented with hardware logic. This, however, is a highly inflexible system which makes it difficult to incorporate any changes in the logic.

The use of a computer offers many advantages, including the flexibility needed to introduce even major changes easily, and also easier maintainability and better man-machine interaction. The computer can provide an automatic log of each transaction on a printer. Each operation can be printed in a desired format, as it is completed, along with a regular print-out of the time. It is thus no longer necessary for the operator to write a record of the various operations being carried out. The computer can be interfaced to a Visual

*(Continued on page 8)*

# Did the Universe Have An origin?

**By Prof. J. V. Narlikar**

Tata Institute of Fundamental Research, Bombay

It is commonly thought that cosmology, *i.e.*, the subject of the origin and the structure of the universe, is an esoteric discipline of no relevance to everyday life. Even scientists sometimes consider it a speculative subject belonging to philosophy rather than science. Nothing could be farther from the truth; and here I propose to give some arguments to explode these myths.

As long ago as 1826, Olbers, a Viennese physician asked a naive question, "Why is the sky dark at night?" You may be tempted to answer this by pointing out that because the Earth rotates we alternately face the dark and sunlit portions of the sky, and that the darkness of the night sky does not need any further thought. Not so! Olbers went on to demonstrate that under very simple assumptions and with simple mathematics, the conclusion is inescapable that the sky should not be dark but extremely bright, regardless of whether we are facing the Sun or not!

### Beginning of Cosmology

This calculation, known as the Olbers paradox, is briefly as follows: Olbers assumes the Universe to be infinitely old, infinite in extent and uniformly filled with equally bright star-like objects. How much light should we get from all these stars? A remote star will not send much light. Indeed, the more remote the star is, the less light we will get according to the inverse square law of illumination. But the farther we look there are more stars at the same distance from us—this number increases in proportion to the square of their distance from us. The two effects exactly cancel each other so that stars at a given distance contribute the same amount of total light regardless of whether they are far or near! From this result Olbers drew the inevitable conclusion that since stars are supposed to be distributed out to infinite distance, their combined light reaching us will also be infinite. In other words, the sky should be infinitely bright regardless of whether the Sun exists or not.

Clearly something is wrong with this argument. If the sky were so bright we could not survive. Yet, it was not possible to locate the fault in Olbers's reasoning until modern cosmology was born. I will return to this question later.

When was modern cosmology born? The important discovery leading to its birth was made by the U.S. astronomer Edwin Hubble in the late 1920's. He found that light from distant nebulae showed a systematic increase in its wavelength. According to the well known phenomenon—the Doppler effect, when a source of light moves away from us, that light shows such an increase in wavelength. Hubble therefore concluded that these nebulae are receding from us. He also found that their velocity of recession increases in proportion to their distance from us. (We are familiar with the Doppler effect in sound. The pitch of the whistle of a railway train sounds shriller when the train approaches; it sounds flatter when the train recedes from us.)

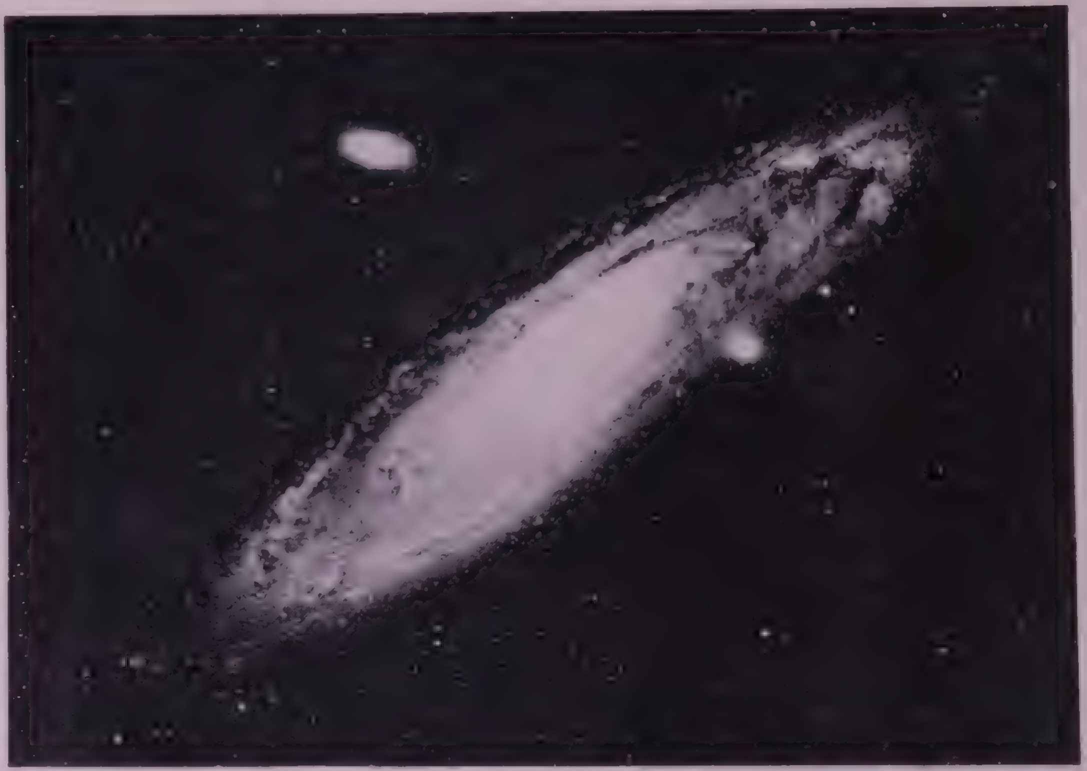


**Fig. 1. The Andromeda nebula, one of our near neighbours in the world of galaxies. (photograph from the Hale Observatories).**

How far is a typical nebula? How big is it? We ourselves are inside one. Our Milky Way system—our Galaxy as it is called—consists of some 100,000,000,000 stars of which our Sun is one. It is a bun shaped object, some 100,000 light years across. (A light year is the distance travelled by light in one year. At a speed of nearly 300,000 km per second this distance is about 10,000,000,000,000 km!). Hubble was looking way out of our Galaxy and his nebulae were galaxies like our own, located millions of light years away! In Fig. 1 is shown the photograph of the Andromeda nebula which is one of our near neighbours at some two million light years.

What do Hubble's observations mean? Is there something significant with our location to force all other

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Based on the Third Vikram Sarabhai Memorial Lecture given by Prof. Narlikar at the Institution of Engineers (Bombay) on 22nd August, 1977.

galaxies to move away? This pre-Copernican conclusion turns out to be unwarranted. If we perform a thought experiment and imagine what the Universe would look like from any other galaxy, we would see the same thing. All other galaxies would be moving away from our new vantage point. Indeed, a proper interpretation of Hubble's data would be to say that the entire universe—with the galaxies embedded in it—is expanding.

Why should the universe expand? Will it always expand? What was it like in the past? To answer such questions within the scientific frame work mathematical models based on Einstein's theory of relativity, were constructed. Friedmann did pioneering work in this field and hence these models are called Friedmann models. In these models the universe started with a gigantic explosion and the resulting expansion is now slowing down. There are two possibilities. The expansion may slow down but not stop altogether. In that case gradually all galaxies will move away so far from one another that each one will be isolated in its part of the universe. In the other possibility, the galaxies will stop receding and come together again: expansion will give way to contraction. The contraction will culminate in a big implosion.

### ‘Singularity’

The Friedmann models are also called the ‘big bang’ models to indicate their origin in a big explosion. The explosion is believed to have occurred sometime around 10-15 billion (=1000 million) years ago. Nothing existed before this big bang epoch—physics is unable to throw any light on the mechanism of the big bang or on its cause. The mathematics of the picture breaks down. Such a situation is called ‘singularity’.

Should such a singularity exist in a physical description? Its presence elsewhere in science will be taken as a shortcoming of the description and attempts are usually made to improve on this. In this case many scientists take the view that ‘singularity,’ at the origin of the universe is inevitable and irremovable. The event is so profound that science may not prove equal to describing it. There are others who object to this viewpoint and argue that the origin of the universe (if indeed such an event did take place) is as much within the purview of science as its subsequent evolution is. These people regard ‘singularity’ as an indication of an incompleteness of Einstein's description of space-time and physics. Personally I share this view.

It was this view which led three British scientists—Hermann Bondi, Thomas Gold and Fred Hoyle in 1948 to propose a rival cosmological theory. It was the steady state theory of the universe. In this the Universe did not have an origin at all! It has always been there and will always be there. Moreover, as the adjective ‘steady’ implies, the Universe should look always the same. It steadily expands and in order to maintain a constant density, new matter is continually being created. Notice the difference. In the big bang universe all matter was created explosively in a single event and this process is beyond the purview of science. In the steady state universe matter is continuously created and this mechanism can be—and has been—described by mathematical equations.

But theorizing apart, what do observations tell us? Did the universe explode into existence or is it in a steady state? Or is there some other entirely different description? I will briefly describe some of the observational attacks on this problem.

The first and the oldest consists of extending Hubble's observations to the more remote parts of the universe. The astronomers at the Hale Observatories in the United States have extended Hubble's observations to distances more than hundred time Hubble's original range. The hope behind this experiment was to see if the slowing down of the expansion of the universe is detectable. The big bang theory says that the expansion should be slowing down. The steady state theory on the

(*Continued on page 4*)

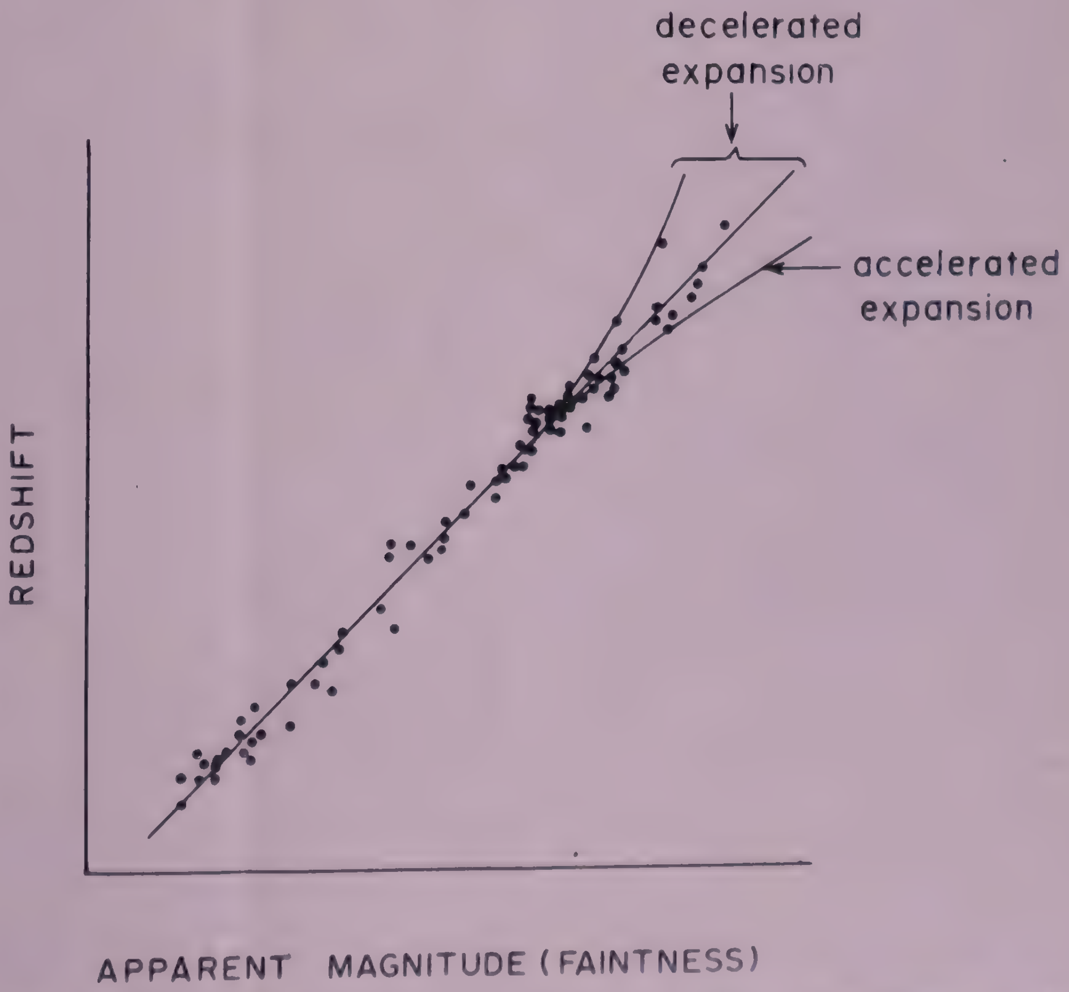

**Fig. 2.** The redshift-magnitude plot based on the work of Kristian, Sandage and Westphal (reported at the IAU/CNRS Colloquium in Paris, 1976).

# ‘The Universe Is E

(*Continued from page 3*)

other hand requires the expansion to accelerate. What do the observations indicate?

In Fig. 2 (p.3) is shown an observational plot superimposed on theoretical curves. The steady state curve is on extreme right. The other curves correspond to the big bang models. A fair assessment today is that this plot is inconclusive. There are several observational and theoretical uncertainties which make a definitive conclusion impossible at present. It is also hoped that observations from the large space telescope proposed in the U.S. may resolve some of the uncertainties.

### Uncertainties

Another important test was undertaken recently by Govind Swarup and his group at the Tata Institute of Fundamental Research, Bombay using the half kilometre array of antennas which constitute the radio telescope at Ootacamund (see Fig. 3). The aim here was to measure the angular size of radio sources and to see how it changes with distance. In our local neighbourhood we use Euclid's geometry. One of its consequence is as follows: If we move an object away from the eye of an observer, he finds it getting smaller. This is because the angle subtended by the object becomes smaller as the object moves away. In the same way, the angle subtended by a remote galaxy should be smaller than that subtended by a nearby galaxy of the same size. Not so! In the big bang universe the angular size does not steadily decrease to zero as the object moves to infinite distance. It starts becoming smaller and then again becomes bigger! This is because geometry is not that of Euclid but that of Riemann. Many results we learn at school for Euclid's geometry are not valid for the Riemannian geometry. In Fig. 4 are shown three curves for the variation of angular size with distance.

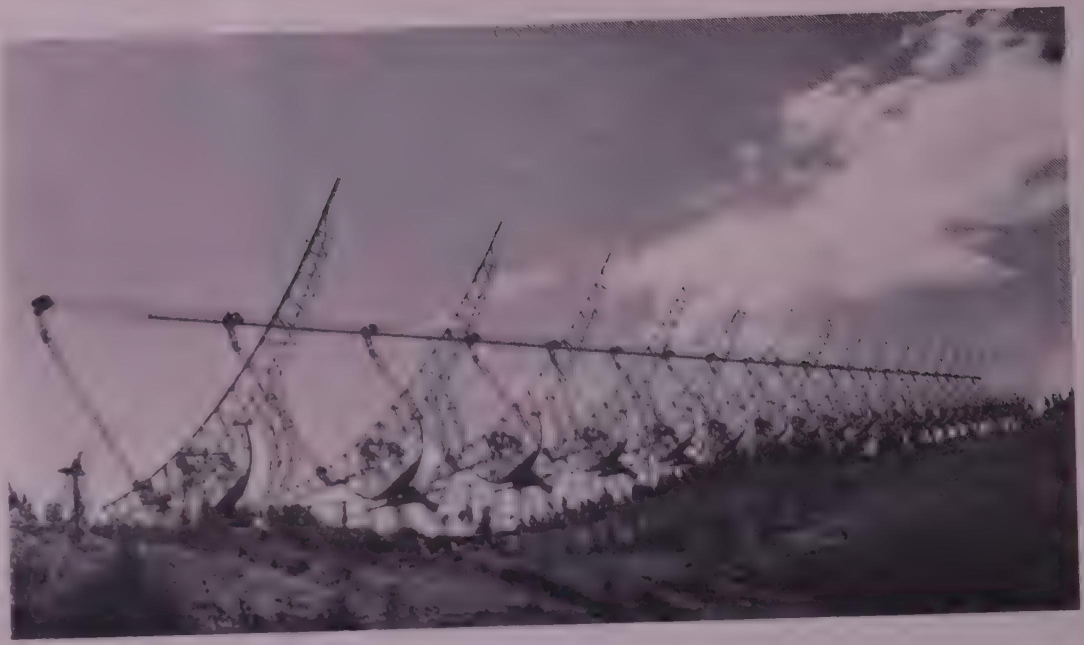

**Fig. 3. The Ooty telescope**

Can we test which curve is suitable for our universe? Swarup *et al* hoped to settle the issue by looking at radio galaxies and quasars which are commonly believed to be very far away. The Ooty radio telescope is ideally suited for measurement of angular size of radio source by occultation with the Moon. As the Moon crosses the line of sight to the radio source, its power output drops. This enables an accurate determination of the source size.

Unfortunately, there are a number of uncertainties which make the interpretation of the data controversial.

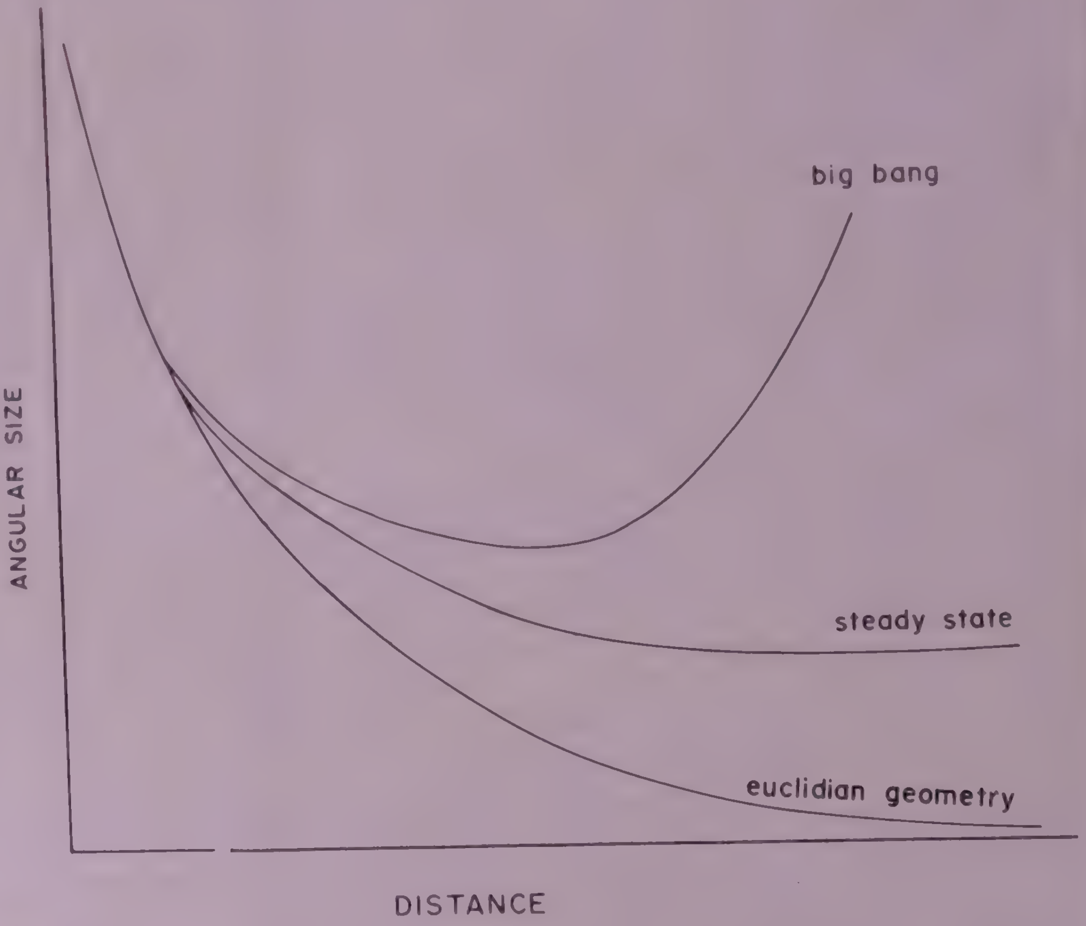

**Fig. 4. The three curves show how the angular size changes with distance in three different cases**

# anding’

There is no direct determination of distance of a radio source. It has to be inferred from its intrinsic power and the recorded flux output. This would be reliable if there were such a thing as a ‘standard candle’ for radio sources. In fact these sources vary enormously in their intrinsic power (by a factor of 10,000 or more). They also vary in intrinsic sizes. So, to a large extent the conclusion to be drawn depends on what you assume for the various parameters which enter the theory.

Swarup *et al* have concluded that their data supports big bang models and that it rules out non-evolutionary models of the steady state type. Chitre and I have disagreed. We believe that in view of the above uncertainties, and the large scatter in the data the steady state model is not ruled out. It would be interesting to see if future improved data from Ooty and elsewhere leads to more clear-cut conclusions.

I finally come to what is considered to be the strongest evidence in favour of the big bang. In the 1940s, George Gamow had speculated that in the first few moments of creation there must have been a huge store of high temperature radiation. This would have cooled down by now and should be observable at present.

In 1965, Arno Penzias and Robert Wilson did indeed observe radiation of this type in the microwave region. This discovery was accidental, as many important astronomical discoveries have been. Yet it inspired measurements by other groups at different wavelengths and the resulting data is shown in Fig. 5. The continuous curve through the points is the theoretically predicted black body curve which has temperature 2.7 K (absolute).

It still remains to establish whether the data agrees with the curve at short wavelengths. This cannot be done with ground-based astronomy. One has to go above the absorbing atmospheric layers to detect such radiation. Space physics will help us here in the near future.

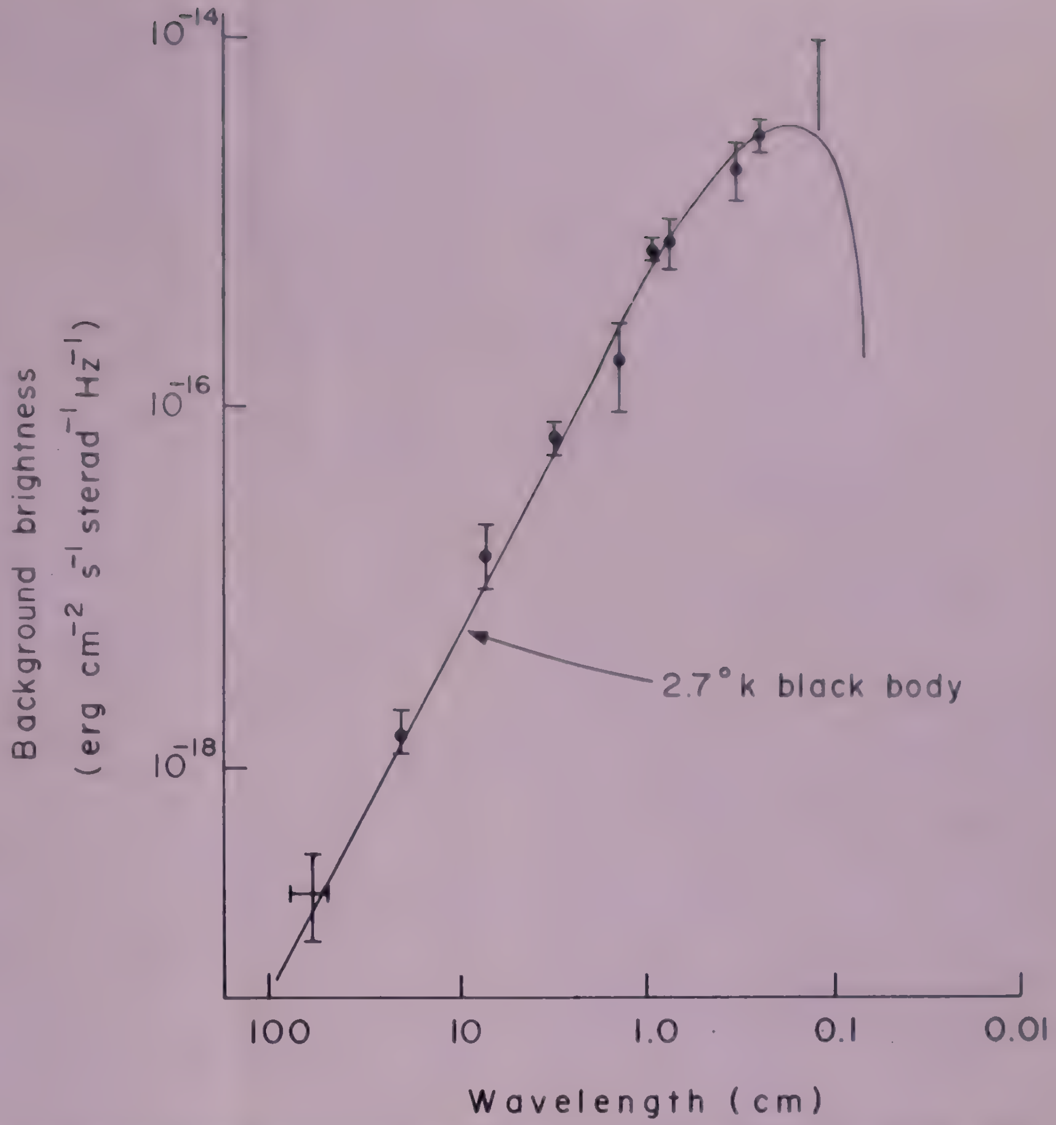

**Fig. 5. The microwave background measurements. The theoretical curve gives a good fit at long wavelengths. This needs to be checked at short wavelengths on the right of the peak**

If the black body curve is established it will pose a major problem to the steady state theory. Can it explain this radiation without recourse to a high temperature era? If it cannot, then it must be abandoned. Personally I am hopeful that this problem will not be insurmountable.

Let me now return to the Olbers paradox. Where did his calculaton go wrong? The answer is: he did not know that the universe is expanding. Because of Doppler effect the light from remote sources is further attenuated, and this produces a much smaller contribution from them than calculated by Olbers and his successors. Thus the answer to the question ‘Why is the sky dark at night?’ is ‘Because the Universe is expanding.’

I have given the state of the debate on the origin of the Universe, as it is at present. Clearly it would be foolish to assume that the last word has been said. The answer to the question raised in the title would be given in the affirmative by the majority of astronomers today. I belong to the minority who would advocate caution in arriving at this conclusion.

Until World War II all inputs into cosmology came from visual astronomy. Then came the remarkable growth of radio astronomy which added considerably more to the cosmologists’ store of knowledge. Both these disciplines of observational astronomy have been ground-based. In the last two decades space physics has begun to provide new insights into the structure of the universe. The astronomer can now look at the Universe from above the atmosphere through X-rays, infrared rays, gamma rays etc. Even the optical astronomer hopes to cash in on space technology through the

(*Continued on page 7*)

# "IAEA Should Allay Unfounded Fears & Misgivings On Waste Disposal"

*—Dr. H. N. Sethna*

THIS session of the General Conference marks the 20th Anniversary of the International Atomic Energy Agency. In the first two decades of its existence, the Agency has grown significantly, both in content and form, adding new and important dimensions to the scope of its activities and the sphere of its responsibilities. As we commemorate its 20th Anniversary, it is also a moment for reflection—an occasion for all of us to reaffirm our faith in the organization and rededicate ourselves to the cause for which this organization was created.

My country has been in the field of nuclear energy for over a quarter of a century. At the end of the second World War, when most nations still looked upon atomic energy as a force for destruction, India was already thinking in terms of harnessing atomic energy solely for economic development, and we have never deflected from our commitment to the peaceful uses of atomic energy. In this spirit, we salute this occasion marking the 20th Anniversary of the International Atomic Energy Agency as an instrument for promoting peaceful uses of atomic energy.

This is also a fitting occasion to pay a special tribute to Dr Sigvard Eklund under whose dynamic and able leadership, the Agency has grown to its present stature. Over the years, he has brought to this organisation, far-sightedness, knowledge and experience which stem from long service and great responsibility. He is most eminently suited for this role, and the Agency is fortunate to have his continued guidance and direction. We wholeheartedly welcome his re-appointment for a further period of four years, and we look forward to celebrating his 20 years as Director General.

May I take this opportunity also to express our appreciation for the excellent manner in which the Secretariat has presented its Annual Report and the assistance and co-operation we have always received from the Agency.

**We note that the study relating to the establishment of nuclear fuel cycle centres has now been completed. However, we cannot but notice that techno-political considerations are now emerging which might influence the emphasis on this programme.**

The work on safety codes and guides is progressing well. We in India have considerable experience on safety problems and we believe that this could be of use to other developing countries.

My delegation is happy to note that on the basis of the recommendations contained in the Memorandum submitted to the Director General at Rio in September 1976 by Member States of the RCA, the RCA has been continued for another period of 5 years from June 1977. In response to the Agency's suggestion, India has drawn up a suggested plan of action for the period 1977-82 for consideration of RCA Members. We recommend that a scientific meeting be held in the region at as early a date as possible to finalise the plan of action for the next 5 years. This would enable the Agency to assess the financial implications and find ways and means of making available adequate funds for implementing the plan.

The most important event in the Agency's programme during the year was the international conference on nuclear power and its fuel cycle convened at Salzburg during May. This conference has contributed greatly to restore confidence that nuclear power is in fact necessary and an irreplaceable source of future energy supply to mankind both in the short and the long term. This stems from the recognition that nuclear energy is indispensable to meet world energy needs which would grow rapidly over the coming decades.

**Frankly, there seems no immediate and proven alternative to nuclear energy. Not only is nuclear power cheaper, safer and environmentally more favourable in many situations, the impending crisis in energy resources also makes it imperative to develop nuclear energy as a part of national programmes in many countries.**

This being the situation, I believe the Agency could play a greater role in bringing to public domain more information on research and development in the field of nuclear waste disposal so as to allay unfounded fears and misgivings which are being voiced in certain quarters these days.

A matter of concern is the provision of technical assistance to developing countries. In this regard, the Director General at Salzburg has himself expressed disappointment at the failure to provide enough resources for technical assistance to developing countries.

The two major spheres of the Agency's responsibilities—the promotional

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Excerpt from Statement by Dr H. N. Sethna, Chairman, Atomic Energy Commission and Leader of the Indian Delegation at the 21st Session of the General Conference of the International Atomic Energy Agency, 27th September 1977.

and the regulatory—are the provision of technical assistance and the application of safeguards. These two facets of its activities are equally important. In recent years, while the regulatory activity of the Agency has expanded greatly with increasing budgetary provision from year to year, regrettably, there is no evidence of recognition of the growing need for technical assistance. On the contrary, considering the prevailing inflationary trends and currency fluctuations, the technical assistance programme of the Agency, even with some modest increase in voluntary contributions, has not shown any effective growth. It is essential that voluntary contributions should reflect in real terms an increase which should be capable of meeting all technically feasible projects requested by the developing countries.

The time has come when the problem of financing technical assistance is resolved on a long-term basis and we do not have to labour this issue each year. I believe various suggestions are presently under study. Meanwhile, for the coming year, the Board of Governors has recommended a target of U.S. dollars 7 million for voluntary contributions in cash with an appeal for a further sum of U.S. dollars 500,000. We, on our part, shall continue to support the Agency's technical assistance programme to the best of our capacity. We have been providing fellowships and services of experts to other developing countries through the Agency's technical assistance programme, besides providing facilities for scientific visits. In addition, my Government has recently agreed to implement a project in a developing country which the Agency could not take up for lack of funds. We are glad to announce a contribution of U.S. dollars 60,000 in our national currency to the General fund for 1978 which is higher than our normal share. It is our hope that the target for voluntary contributions would be fully realised and also that the Agency would be able to gear up its operating machinery, eliminating impediments in its delivery capacity and unnecessary delays and bottlenecks in implementing its technical assistance programme.

**In the past, I have had occasion to express concern over the tendency to apply restrictive policies in regard to provision of technical assistance in the form of fellowships, scientific visits etc. There is now an additional cause for concern as the application of safeguards is being extended to technical assistance involving transfer of technological information in the so-called " sensitive technological areas ". We are concerned and would like to be assured that this extension of safeguards would not in any way hinder the development of nuclear programmes of developing countries. It is also necessary to ensure that well-established principles relating to the provision of technical assistance are preserved and there is no discrimination in any form in the provision of technical assistance to all countries.**

We note that the Director General has constituted a standing advisory group on safeguards implementation to advise him on the technical aspects of Agency safeguards. We are confident that the deliberations of this group will concentrate on the important task of assessing the technical effectiveness of safeguards implementation within the scope of the present system and leaving aside other issues.

### Nuclear Progress

Finally, I would like to mention a couple of new things which we have been doing in our country.

Our Nuclear Fuel Fabrication Complex at Hyderabad has now entered into its second year of full commercial production. The Plant manufactures uranium oxide pellets and a wide variety of zirconium alloy products from local ores. The Plant has delivered all the tubes and calandria tubes for one of the Madras reactors. The Complex fabricates all the fuel elements needed for Tarapur and Rajasthan Stations. These fuel assemblies for Tarapur and Rajasthan Stations are giving satisfactory performance at full rated irradiation conditions.

The first commissioning run at the Power Reactor Fuel Reprocessing Plant at Tarapur has been completed. The various systems are performing well and an initial campaign is currently being reprocessed. Our expectation that fuel reprocessing costs, including waste management, would be much lower than the indicative costs of such services in other countries has proved to be correct.

In conclusion, I would like to once again emphasise the need for the Agency to give greater emphasis to its promotional activities, particularly provision of technical assistance to developing countries. This is essential so as to accelerate and reinforce national effort in these countries to harness nuclear technology for the improvement and betterment of their standards of living. The Agency has an important international responsibility in this respect and I am confident that it will continue to meet its obligations with a sense of dedication it has always displayed. On our part, we would like to pledge our continued support and assistance to the Agency's activities. ●

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## *Space Physics*

( *Continued from page 5* )

creation of a space telescope. In India, as in the West and in Japan, a beginning has been made to utilize the new techniques of space physics—Bhabha and Sarabhai were quick to spot their potentialities. At present it is too early to say what new results will be forthcoming in the future and how they will modify our understanding of the nature of the Universe. After all, astronomy has flourished on unexpected discoveries! ●

**NUCLEAR INDIA**

**is a monthly publication of the Department of Atomic Energy, published around the 20th of each month. To ensure prompt attention, all communication should be addressed to the Editor, NUCLEAR INDIA, Department of Atomic Energy, Chhatrapati Shivaji Maharaj Marg, Bombay-400 039. While intimating change of address, the code and number given on the wrapper should be mentioned. Bombay recipients may contact 25 04 77 for prompt action.**

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# *Computer Controlled FM Operation*

*(Continued from page 1)*

Display Terminal (VDT) : it can gather all relevant system information, process it and present it in a compacted form on the VDT for ready reference.

For performing complex logical operations, a computer system is inherently more reliable than its hardwired counterpart. Even while actively involved in control of a process, a computer can run diagnostic programmes in the background. These programmes help the computer to diagnose it's faults as well as those of related equipment. The maintenance of a computer system is much simpler because of its modular structure.

The present system is built around the minicomputer TDC-312, with 12 K main memory and two magnetic tape units. The computer is supported by some peripherals which enable it to interact with the process as well as the operator. A Digital Input Output Unit routes the flow of signals and commands between the fuelling machine and the computer. The watchdog times out in the event of computer malfunctioning and acts as a check on the proper execution of the software programmes. The Interval Timer interrupts the computer every 20 milli-seconds to provide a time slice. The software strategy centres on these time slices. At the beginning of each time slice, the computer reads all the input signals from the process and checks for changes against the status obtained at the previous check. It then executes the programmes associated with each changed input, generates outputs and delivers them to the actuators on the fuelling machine.

The present computer system can operate only one fuelling machine. A computer system for the control of the entire Fuel Handling System at the Integral Thermal Facility of the Reactor Engineering Division is now in an advanced stage of development. It is based on a network of one minicomputer TDC—312, and two microcomputers built around the 8085 microprocessor. Each microcomputer handles one-half of the Fuel Handling System, while the minicomputer looks after the overall system tasks. A computer configuration for the Narora Power Station Fuel Handling System is also being considered. ●

**NUCLEAR PHYSICS AND SOLID STATE PHYSICS SYMPOSIUM-1977**

**The Nuclear Physics and Solid State Physics Symposium organised under the auspices of the Department of Atomic Energy, will be held this year at Poona University, Pune. The dates of the Symposium are December 26-30, 1977. The last date for receiving abstracts is October 17, 1977. The contributions should be sent to Dr. S. Kailas (Nuclear Physics) or Shri P. R. Vijayaraghavan (Solid State Physics) Nuclear Physics Division, Bhabha Atomic Research Centre, Bombay-400 085**

# Science Notes

## *Indian R & D Statistics*

- Total expenditure on Science and Technology in India during 1974-75 is estimated at Rs 344 crores. About 90 per cent of this was financed by the Central and State Governments, and the balance 10 per cent by private sector. This accounts for 0.54 per cent of the nation's Gross National Product.

- The Central Government spent 2.57 per cent of its budget on R&D during 1974-75.

- In the Central Sector, the major scientific agencies such as Department of Atomic Energy, Space, Council of Scientific and Industrial Research, Indian Council of Agricultural Research, etc. accounted for nearly 82 per cent of the total expenditure on research and development.

- Expenditure on R&D in States is estimated at Rs 29 crores. This represents 10 per cent of the total expenditure by the Government sector.

- 300 companies registered with the Department of Science and Technology are reported to have spent Rs 36 crores on R&D during 1974-75.

- Total stock of S&T personnel in India has been estimated at 13 lakhs at the end of 1974.

- The number of universities and Institutions deemed to be universities has increased from 20 in 1947 to 100 in 1974.

- About 121,000 personnel were employed in R&D establishments. These include personnel engaged in R&D, those engaged on auxiliary scientific and technical activities as also those employed for rendering administrative and other non-technical support.

- 40 per cent of the personnel engaged primarily in R&D possessed post graduate and higher qualifications in Science, Agriculture, Engineering and Medicine.

- 38 per cent of the personnel engaged in R&D were engineers, 23 per cent agricultural scientists, and 1 per cent were medical doctors.

- 35 per cent of the personnel engaged in R&D were employed by the major scientific agencies.

- About 4,000 patents were sealed in India during 1974-75. Value of goods produced during 1974-75 from processes licensed by NRDC is estimated at Rs 18 crores.

- A plan provision of Rs 767.64 crores has been made for the S & T programmes in the fifth plan.

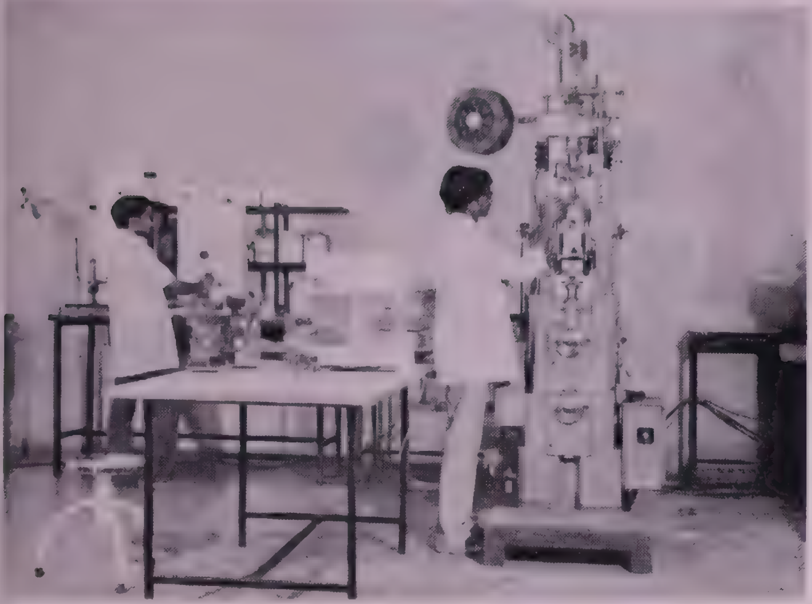
*(from "Handbook on Research an Development Statistics 1974-75" of th Dept. of Science & Technology, an "Sciencetech Bulletin)"*

Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India,
Chhatrapati Shivaji Maharaj Marg, Bombay 400 039, and printed by him at G. Claridge & Co. Ltd., Bombay 400 001

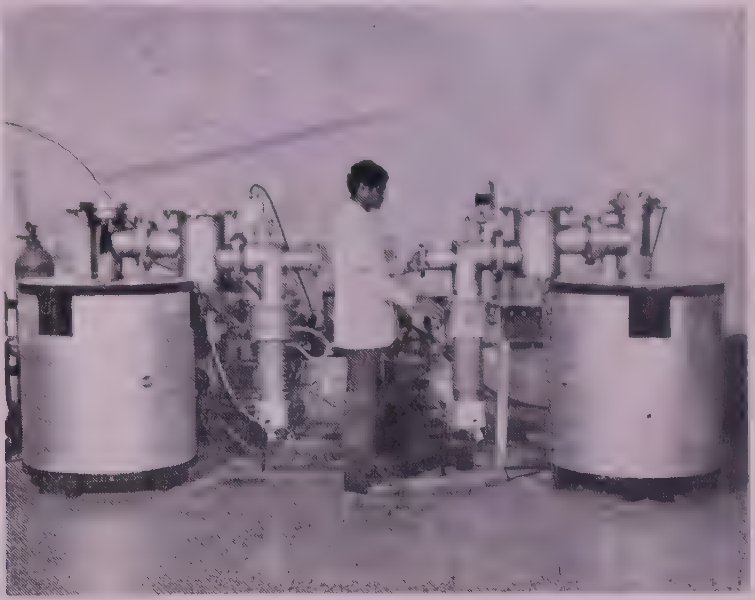
**Registered No. R. N. 9002/62**

# NUCLEAR INDIA

VOL. 16 No. 2 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY OCTOBER 1977



**Powder characterisation, blending and pressing**



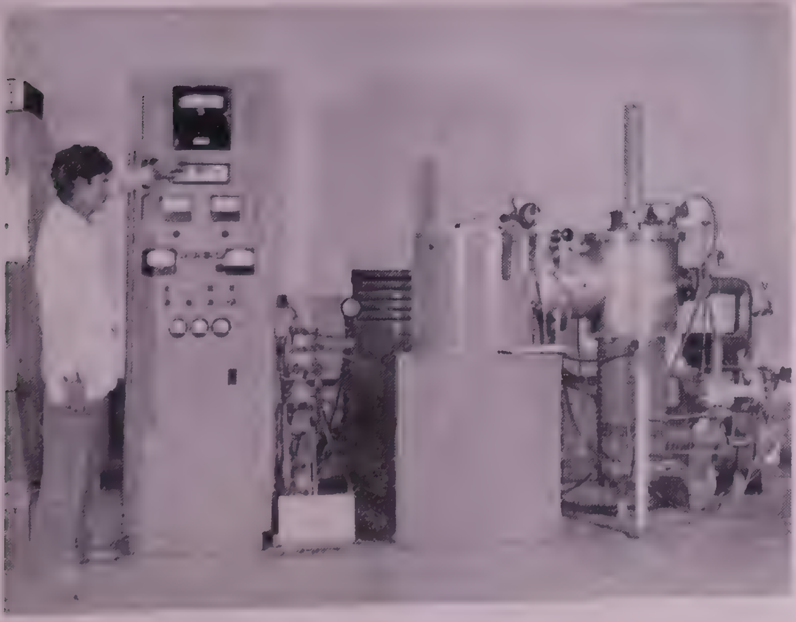
**High vacuum dewaxing**

# *Tantalum Anode Plant Commissioned*

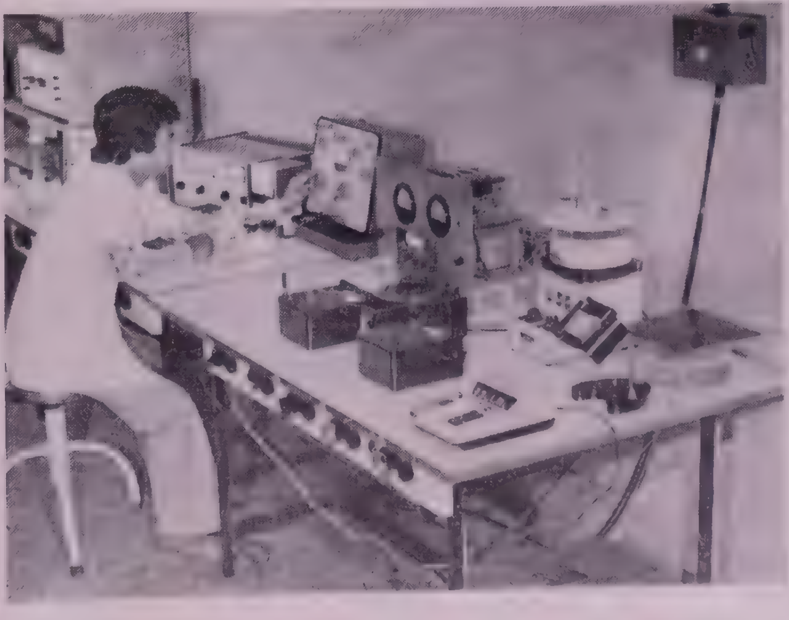
A COMMERCIAL scale plant for producing capacitor-grade tantalum anodes has been commissioned at the Electronics Corporation of India Ltd. (ECIL), Hyderabad.

Tantalum, a corrosion-resistant metal, is needed in an ultra-pure form by the electronics industry for fabricating highly sensitive components such as electrodes, capacitors etc. Tantalum powder and anode are high technology products which have been developed by the Nuclear Fuel Complex (NFC) of the Department of Atomic Energy at Hyderabad. The NFC has a Special Materials Plant (SMP) which produces ultra-pure materials of commercial

(*Continued on page 8*)



**High temperature high vacuum sintering of anodes**



**Electrical evaluation of anodes**

A view of the uranium mine and mill at Jaduguda, photographed a few years back

# UCIL Completes A Decade of Pioneering Work

THE Uranium Corporation of India Ltd. (UCIL), a public sector enterprise under the administrative control of the Department of Atomic Energy, completed 10 years on 15th October. It was established at Jaduguda, Bihar, with the objective of mining and processing uranium ore. Uranium in the form of fuel is a primary requirement of nuclear power plants, and the establishment of UCIL for producing uranium concentrates marks an important step in India's nuclear programme. UCIL has achieved the distinction of putting Jaduguda on the world map of uranium by successfully commissioning India's first uranium mine and mill.

### Uranium Mine

To bring the mine into production as early as possible, a vertical shaft of 640 metres depth was designed for sinking in two stages : in stage I upto 315 metres, and in stage II from 315 metres to a depth of 640 metres. The advantage of dividing the sinking programme in two stages is that after completion of the first stage of sinking, the shaft can be ready for production of ore from the mine, and work on the sinking of the second stage can go on simultaneously. The first stage of shaft sinking, along with construction of other facilities such as ore pass system, underground crushing and loading station etc. was completed, and the mine was commissioned in 1968.

The second stage of shaft sinking, started in 1971, is almost complete and production from the deeper levels is likely to commence by the end of 1977. With completion of this project almost a new mine of about 325 metres depth has been constructed within a period of six to seven years. Jaduguda is now one of the deep mines in the country.

### Uranium Mill

For processing the uranium ore, a mill was constructed close to the mine: it went into commercial production in May 1968. The process flow sheet is based on the laboratory and pilot plant results obtained at BARC. The mill complex consists of crushing and grinding plants, leaching and filtration units, ion exchange plant, a sulphuric acid manufacturing unit and a chemical laboratory. In processing, the ore is crushed and ground and uranium is leached into solution by addition of sulphuric acid. Uranium from the solution is recovered and precipitated in the form of Magnesium Diuranate, commonly known as "yellow cake". These concentrates of uranium are sent to the Nuclear Fuel Complex at Hyderabad for further processing.

### New Projects

In the last ten years, apart from successfully putting into operation the uranium mine and mill, the UCIL has enlarged its activities. It has undertaken a few projects which have yielded successful results. Some of these activities are: (a) Recovery of accessory sulphide minerals of copper and molybdenum, and also of magnetite from uranium ore; (b) Recovery of uranium values from copper tailings of the neighbouring copper mines.

### Copper, Nickel & Molybdenum

The uranium ore of the Jaduguda mine contains small amounts of sulphide minerals of copper, nickel and molybdenum. Though these minerals

(*Continued on page 4*)

## *Trombay Groundnuts*

# A Home in Gujarat for TG-17

**by S. H. Patil**

Biology and Agriculture Division,
Bhabha Atomic Research Centre

FIVE improved Trombay Groundnut (TG) varieties developed at the Biology and Agriculture Division of the Bhabha Atomic Research Centre (BARC) were introduced on an experimental basis in the Saurashtra region of Gujarat State during the *kharif* season in 1975. The pod yields of these TG varieties were found superior to the popular varieties, Junagadh-11 (J-11) and Punjab-1 (P-1). In this experiment TG-17 produced yields of 2,262 kg and 3,391 kg/ha compared to 1,380 kg of J-11 and 1,763 kg of P-1 at Senosara and Rajkot respectively.

J-11 is a 'bunch' variety maturing in about 110-115 days and is popular mainly in Bhavanagar and Amreli districts. P-1, on the other hand, is a 'spreading' type maturing in 125-130 days and is widely grown in the Saurashtra region. TG-17, which has intermediate maturity of 120-125 days, is therefore acceptable to cultivators growing J-11 as well as P-1. It has short plants with less branches and more "pegs" per axil, including those of the stem (See Fig.). Dark green foliage and limited seed dormancy of 3-4 weeks are additional assets of this 'bunch' variety.

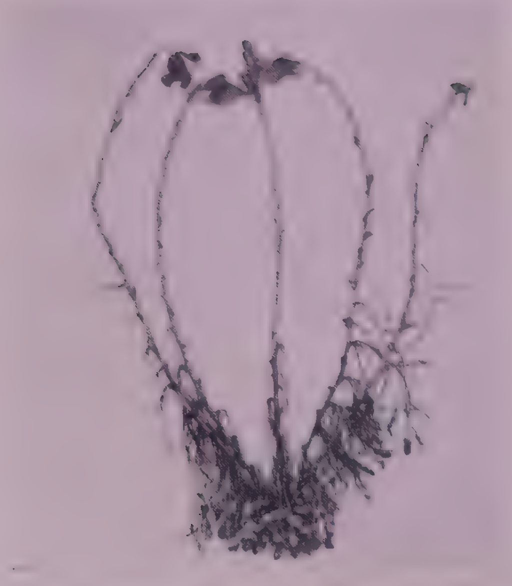
The extension wing of the Vanaspati Manufacturers Association of India (VMA) has taken an active interest in testing the TG varieties and in multiplying and propagating the seed of the better ones. With financial assistance from the Indian Oil and Produce Exporters Association (IOPEA), Bombay, VMA has demonstrated the superiority of TG-17 and other TG varieties in Gujarat as well as in other states. Starting with a small quantity of TG-17 seed in 1975 they produced about 30 tonnes by the end of 1976.

In Gujarat, summer (Feb-May) groundnut is cultivated mainly in the coastal regions of Bhavanagar and Junagadh districts. Eight villages were therefore selected in the Bhavanagar district to grow TG-17 in about 50 hectares during Feb-May 1977. Each cultivator had grown TG-17 in 0.5-2.5 ha; and an equal area was under J-11. About 100 kg/ha diammonium phosphate fertilizer was applied at the time of sowing. Although 30 × 15 cm spacing was recommended, most of the cultivators drilled 100-130 kg kernels/ha at 25 cm between rows and by "hammer" system (sowing cross-wise). The crop generally received 8-12 irrigations. Due to early rains in May the crop was harvested in less than 120 days by several farmers.

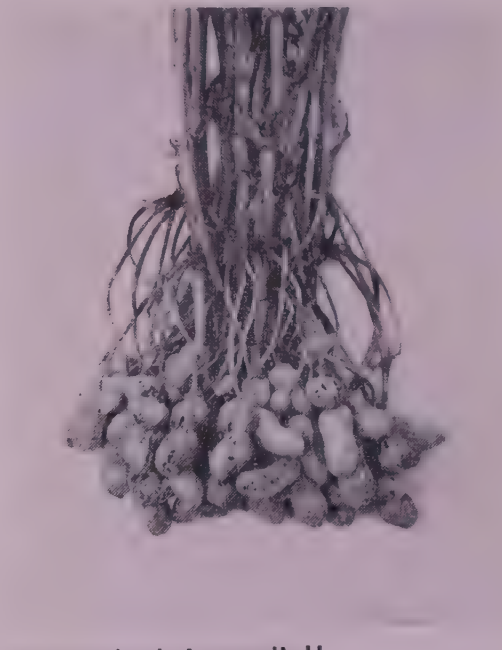
**Junagadh-11 plant**

The pod yield in TG-17 varied from 12.5 to 45.0 quintals/ha. On an average 50 ha under TG-17 yielded 24 quintals/ha compared to 20.5 quintals of J-11 More than 20 per cent of the farms obtained over 30 quintals/ha. The maximum pod yield of 40 and 45 quintals/ha was obtained by two far-

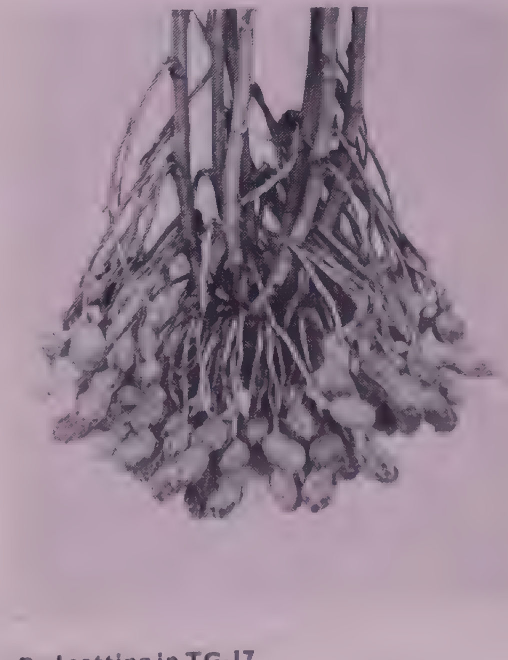
(*Continued on page 8*)



**TG-17 plant with profuse "pegging"**



**Pod setting in Junagadh-11**



**Pod setting in TG-17**

# Byproducts at UCIL

(*Continued from page 2*)

are in accessory form, they are attractive enough to be recovered as byproducts. A pilot plant was set up for investigations and it was found feasible and economical to recover the sulphides from the uranium ore. A by-product recovery plant has been set up and commissioned in 1974. Sulphide concentrates of copper have a ready market and there is a great demand for the strategic mineral molybdenum as it is not produced in India. UCIL is therefore the first and the only organisation to produce molybdenum sulphide concentrates in the country. Studies on the recovery of nickel sulphide are also in progress.

Magnetite is yet another accessory mineral that is being recovered as a by-product of the uranium ore. The mineral is recovered from the tailings, after the recovery of uranium and sulphides of copper and molybdenum. Magnetite is used in coal washeries for heavy media separation. With finalisation of the flow sheet for recovery of nickel, Jaduguda will have achieved success in establishing processes for recovery of all the economic minerals present in the ore.

## Uranium as a By-product of Copper

Just as sulphides of copper, nickel and molybdenum are found associated with uranium ore, some uranium minerals are present in accessory form in the copper ores of Surda and Rakha Copper mines. To study the possibility of recovering uranium as a by-product of copper, laboratory and pilot plant investigations were conducted in the Bhabha Atomic Research Centre (BARC) and the UCIL. These investigations revealed that it is feasible and economical to recover uranium as a by-product from the tailing of copper ore. Based on these studies, a uranium

(*Continued on page 6*)

*Above.* **Loading of uranium ore inside the mine.** *Below.* **The uranium ore being hauled out.** *Left.* **Miners at end of shift. In the background is the mine shaft head frame.**

# Neem—The Tree of Bounty

THE Neem tree, a native of India and ever-green, is known for its varied scientific properties. In rural areas neem sticks are used as tooth brush, and the leaves of the tree are used in the foodgrain containers to save stored grain from pests, neem oil, which is extensively used for soap making, is available from neem kernel which is obtained from the mature seed. After extraction of neem oil, the coagulated remains make what is called neem cake.

It is estimated that in India there are 1.38 crore neem trees. These produce about 4.18 lakh tonnes of neem seed every year; they can yield 83 lakh tonnes of oil worth Rs. 33 to 50 crores and 3.30 lakh tonnes of neem cake worth Rs. 14 to 20 crores, provided the entire seed crop is collected. However, the present seed collection is very indifferent. It is no more than a meagre one lakh tonnes.

### Research on Neem Cake and Neem Oil

The Directorate of Non-Edible Oils and Soap Industry of the Khadi and Village Industries Commission has been carrying on research in Pune on neem cake and neem oil since 1969. The object is to utilise the neem cake in agricultural production and oil for the protection of seeds and grains from stored grain pests. Cooperation of agricultural universities and agricultural departments of various states was sought in this task for taking large scale trials of neem cake blended urea for nitrogen economy on paddy and sugarcane crops.

Application of neem cake blended urea in paddy crop not only increases the yield of paddy but also adds to the protein content of rice. The findings at the Padegaon Sugarcane Research Station in Maharashtra have given promising results. The station uptill now was recommending 400 kg. of nitrogen per hectare for Adsali cane (of 18 months duration). But now with the use of neem cake, a dose of 300 kg. of nitrogen is considered enough. This resulted in a saving of 100 kg. of nitrogen, or 220 kg. of urea costing Rs. 338. Apart from saving on fertiliser, there will be increase in the yield of sugarcane by 2.2 tonnes per hectare, further addition to the sugar content and rise in profit by Rs. 330 per hectare. Use of 22 kg. of neem cake for paddy crop and 140 kg. of neem cake for sugarcane crop per hectare is recommended.

The research has given conclusive proof that neem cake blended urea prevents nitrogen losses from urea. The slow release of nitrogen results from a certain property which exists in the bitter part of neem cake. Similarly, the activity of certain types of bacteria in soil is also controlled by the neem cake and the slow release of nitrogen helps the growing crop. The research findings on crops like paddy and sugarcane have shown that urea nitrogen can be saved to the extent of 25 to 50 per cent with the application of neem cake blended urea.

The neem can be planted in waste lands. One hectare of land with hundred neem trees can yield, after 10 years of plantation, about 5 tonnes of seeds every year.

### Reducing Fertiliser Losses

A tonne of neem cake can be used either for 45 hectares of paddy or 7 hectares of sugarcane. Similarly, all the potential neem cake of 3.30 lakh tonnes can be used in 1.48 crore hectares of paddy or 23 lakh hectares of sugarcane. In India, urea worth Rs. 177 crore is used for paddy crop and Rs. 108 crore for sugarcane. But urea worth Rs. 110 crore and Rs. 54 crore respectively is lost due to leaching or denitrification. The nitrification inhibition property of an indigenous source like neem cake can prevent this heavy loss.

### Neem Oil as Pesticide

About 18,000 tonnes of neem oil are reported to have been made use of in soap-making during 1975. Neem oil is used in some medicinal preparations besides, and due to its insecticidal property, is also effectively used as a pesticide.

Neem oil, if applied to seeds or grains, can protect them from stored grain pests. Such use of neem oil is not unhealthy. 800 grammes of neem oil could be applied to 100 kg. of seed or grain to protect them from pests.

### Poultry Feed

Neem kernel meal after some processing, yields high grade protein suitable for use as a constituent in poultry feed. Research findings have convincingly indicated the suitability of processed neem meal as a substitute for groundnut meal in poultry feed, both for growth and laying. (*PIB*)

**Nuclear India**

**is published around the 20th of each month. To ensure prompt attention, all communication should be addressed to the Editor, NUCLEAR INDIA, Department of Atomic Energy, Chhatrapati Shivaji Maharaj Marg, Bombay 400 039.**

## Symposium on Applications of Radioisotopes

A symposium on the "Applications of Radioisotopes in Chemical and Metallurgical Industries" sponsored jointly by the Department of Atomic Energy and the National Association for the Application of Radioisotopes and Radiation in Industry (NAARRI) is proposed to be held during February 7-8,1978 at the Bhabha Atomic Research Centre. Shri S. M. Rao, Convener, Symposium Committee, Isotope Division, Bhabha Atomic Research Centre, Bombay-85 may be contacted for further details.

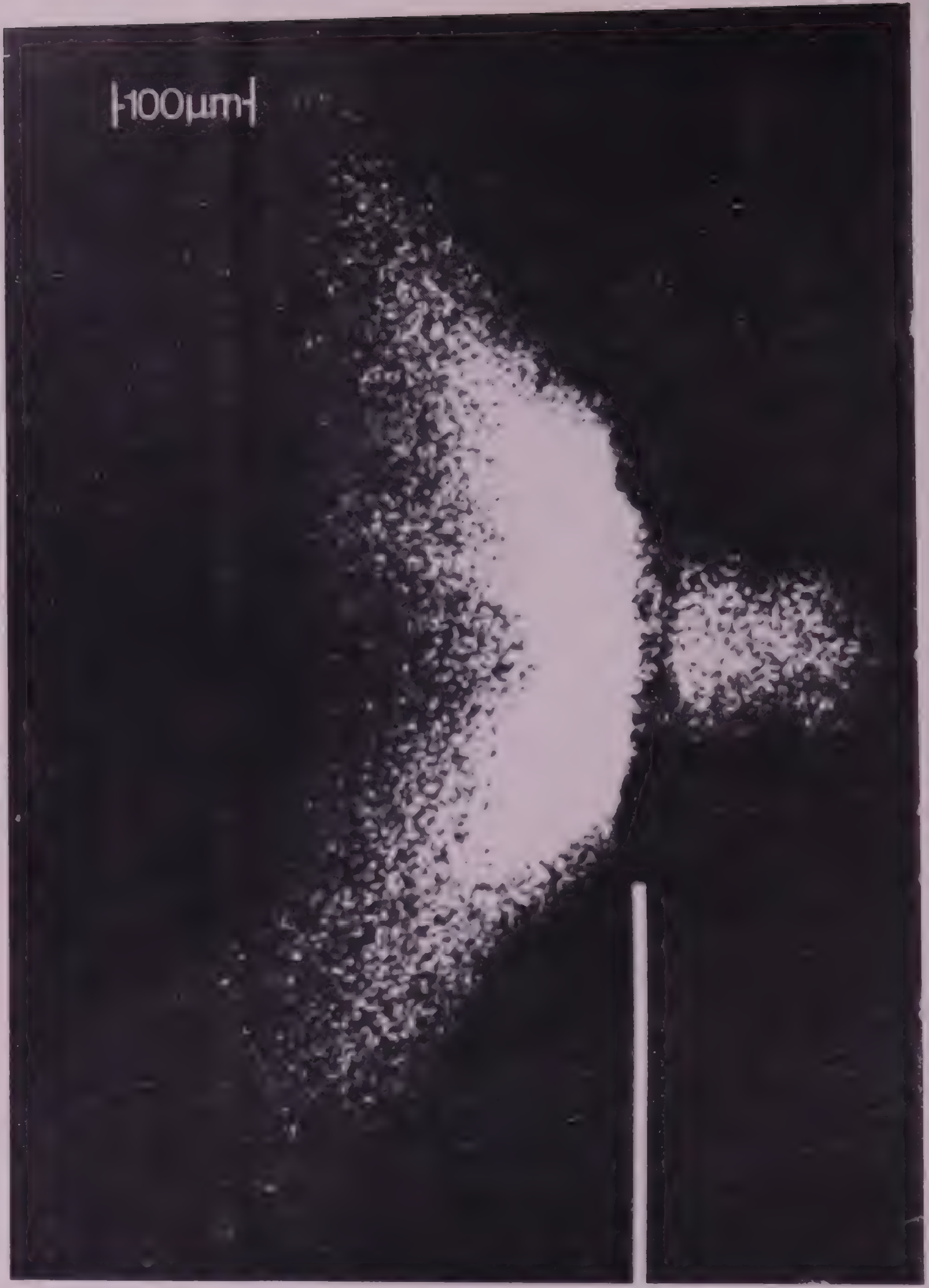
## Use of Neutrons

NEUTRONS provide a unique method for investigating the structure of matter. As they have no electric charge, neutrons can penetrate deeply into a sample and, having a magnetic momentum, can also reveal information on the magnetic properties of matter. When a sample of material is put into a neutron beam, neutrons interact in various ways with matter or are scattered. From the way neutrons are scattered, it is possible to draw conclusions from the microscopic phenomenon and properties of matter, their structure, vibrations of atoms or molecules, energy levels and so on.

The use of neutrons for such studies was achieved some 20 years ago. The International Atomic Energy Agency (IAEA) has organized symposia on this topic every four years since 1962. The IAEA organized its latest symposium on the subject, the fifth in the series, from 17 to 21 October 1977. Some 240 participants from 29 nations and three international organizations met to discuss the many new applications of the neutron inelastic scattering techniques that have emerged during recent years.

The major achievements reported at the symposium were on the presentation of new experimental techniques that make it possible to study entirely new phenomena in the field of materials science. In particular, interesting results were reported in polymers and surface sciences that control, for example, catalytic reactions in chemistry.

Increased international co-operation will be necessary as the new neutron sources providing high intensity neutron beams over a broad energy range are expensive, and beyond the reach of countries with smaller industries. In particular, it may be mentioned that the United Kingdom has announced plans to build a 800 MeV synchrotron accelerator for neutron production which will give new insights into different areas of materials science, including, for example, chemical bonding and the properties of magnetic materials. (*IAEA*) ●



**MORE LASER POWER TO AID RESEARCH. X-ray film of a plasma produced by a beam from a neodymium laser directed (from the left of the picture) onto solid deuterium. The resolution indicated by the 100-micrometre scale was attained by placing a small pinhole between the plasma and the film, as in a pinhole camera. The solid line indicates the plane of the deuterium. Work on laser-produced plasmas has been stimulated in recent years by research aimed at generating power from controlled nuclear fusion. Courtesy : Spectrum.**

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## A Decade of UCIL

(*Continued from page 4*)

recovery plant to treat 400 tonnes of copper tailings per day has been set up near the copper concentrator of M/s. Hindustan Copper Ltd. at Moubhandar, which treats copper ore from the Surda mine. On similar lines, a pilot plant has also been set up to treat copper tailing from the Rakha mines. The mining and milling of low grade uranium ore at Jaduguda have thus resulted in achievement of self-sufficiency in this raw material of strategic importance, and has helped in the development of indigenous knowhow. ●

# Science Notes

## *Electron Microscope*

India has successfully developed the technology for making an electron microscope. The first complete laboratory prototype will be available at Central Scientific Instruments Organisation by the end of this year for users' trial. The fully engineered system will be available at The Central Electronics Ltd. (CEL) a production organisation by the end of next year.

This project was started in October 1975 by the Science and Engineering Research Council of the Department of Science & Technology. It is a multi-institutional project with an outlay of Rs. 30 lakhs.

A number of major research and development and industrial centres have been involved in the designing of this instrument.

These are :

(*a*) Banaras Hindu University, Varanasi ;

(*b*) Central Scientific Instruments Organisation, Chandigarh ;

(*c*) Central Electronics Engineering Research Institute, Pilani ; and

(*d*) National Physical Laboratory, New Delhi.

The Central Electronics Ltd. has been given the responsibility of development of production technologies for the Scanning Electron Microscope emanating from this project. To decrease the time between R & D and the final production, the Central Electronics Ltd. has been associated with this project right from the beginning. Some production technologies of different components already developed by BARC are being utilized by the CEL, which is also availing of the assistance of external experts in the field of Scanning Electron Microscopy from IIT, Delhi and BARC, Bombay.

The Electron microscope is a highly sophisticated system which can magnify objects several times and resolve dimensional images of such small objects as viruses, molecular and crystal structures and other metallurgical and biological specimens in research and industry. In recent years, electron microscopes have become indispensible tools for scientific and industrial research.

The principles of electron microscopy were discovered some 50 years ago but because of their highly sophisticated nature and the stringent specifications relating to material, components and the systems, only four or five manufacturers in the world make electron microscopes. One such microscope costs anywhere between Rs. 10 lakhs to Rs. 20 lakhs. India has considerable demand for electron microscopes.

With the successful development of technology for this microscope, very sound scientific and technological base for future development of sophisticated systems has been created in India by the Dept. of Science & Technology.

(*Sciencetech Bulletin, September* 1977)

## *Solar Milk Dryer Developed at Anand*

The Amul Research and Development Association of the Kaira District Cooperative Milk Producers' Union Ltd., Anand, Gujarat have developed a solar energy pre-heater for drying of milk. This project was entrusted to Amul, Anand and is funded by the Department of Science and Technology of the Government of India under the scheme of development of new energy sources in which emphasis is placed on solar energy utilisation.

Air is sucked in and heated through a roof-top collector which consists of 28 metres × 11.5 metres of corrugated asbestos sheets covered with glass plates fixed in wooden frames. Iron shavings are placed between the glass plates and asbestos sheet and the sheets are blackened with paint. The solar energy heated air goes to the spray drying of milk unit in which further rise in temperature is obtained by a conventional steam heater. As the solar

(*Continued on page 8*)

## *New IAEA Board of Governors for 1977-78*

At the 21st session of the General Conference, which ended on 30 September, twelve Member-States were elected to the Board of Governors : Austria, Bulgaria, Ecuador, Ghana, Iran, Kuwait, Norway, Peru, Republic of Korea, Romania, Senegal and Tunisia.

The following countries are now members of the IAEA's Board of Governors :

Argentina
Australia
Austria
Belgium
Brazil
Bulgaria
Canada
Czechoslovakia
Ecuador
Egypt
France
Germany, Federal Republic
Ghana
India
Iran
Italy
Japan
Kuwait
Malaysia
Mexico
Niger
Nigeria
Norway
Pakistan
Panama
Peru
Portugal
Republic of Korea
Romania
Senegal
Tunisia
Union of Soviet
  Socialist Republics
United Kingdom of
  Great Britian and Northern Ireland
United States of America

*(Continued from page 7)*

energy heated air is hotter than the outside air by 50°C on a sunny day/30°C on a cloudy day, less heating is required to be done by the steam heater and the saving in fuel cost is about Rs. 70,000 per year.

(*Sciencetech Bulletin, September* 1977)

## *Wind Electric Generator*

The National Aeronautical Laboratory, Bangalore has designed and developed a Wind Electric Generator power source capable of producing 20-30 volt ampere hours of energy. This can serve as a power supply in place of dry cells in operating isolated electronic systems.

The generator will be useful for use in communication repeater stations : navigation buoys on seaways, aviation lighting equipment, power source for radios in isolated communications, radio reporting rain gauge stations and similar automatic measuring systems. As and when the wind energy is available, the wind electric generator charges a long-life battery from which the energy can be drawn.

The wind generator has been designed with emphasis on the minimum maintenance requirement and has the following features:

(*a*) The blades are made of aluminium alloy and are resistant to corrosion.

(*b*) The blade assembly has a feathering mechanism to reduce the angle of attack for high wind speeds.

(*c*) The head assembly is completely enclosed.

(*d*) The steel parts are painted with oven baked epoxy paint.

(*e*) The generator is coupled such that slip rings and brushes are avoided.

The prototype of the system is undergoing final operational tests.

(*NAL, Bangalore*)

## *Tantalum Anode Plant at ECIL*

*(Continued from page 1)*

importance, as well as materials of strategic value needed for defence applications. Among the items on which the SMP has been working so far are:

(1) 99.999 per cent purity materials (Antimony, Arsenic, Bismuth, Cadmium, Gallium, Gold, Indium, Lead, Selenium, Silver, Tellurium, Tin, Zinc, Boron-tribromide and phosphorus oxychloride).

(2) Capacitor-grade tantalum powder and tantalum anodes,

(3) Electronic-grade manganese nitrate and scintillation grade sodium iodide, and

(4) Micron size detonator and getter grade zirconium powder.

The technology and the trained personnel for the Tantalum Anode Plant have been passed on to the ECIL by NFC. The plant is based on laboratory and small scale developmental work at the Metallurgy Division of the Bhabha Atomic Research Centre (BARC) which the NFC adopted and raised to a commercial level process. The NFC has operated the unit as part of its Special Materials Plant at an annual scale of 0.5 million pieces, prior to helping ECIL to establish the facility.

The tantalum anode production process involves the following critical steps:

(*a*) Evaluation and characterisation of the tantalum powder.

(*b*) Doping with suitable binder and granulation,

(*c*) Pressing the granulated powder to shapes of predetermined geometry, size, weight and porosity with *in situ* embedded tantalum wire lead,

(*d*) Removal of the binder (dewaxing), and sintering under high vacuum high temperature conditions ($5\times10^{-5}$ to $10^{-6}$ torr and 1800 to 2150°C) to obtain the required strength, porosity and electrical characteristics. For quality control purposes test batches of the sintered anodes are oxidized electrolytically under specified current/voltage conditions and evaluated for DC leakage, dissipation factor and capacitance.

The process is a good example of a controlled powder metallurgical process for achieving certain desired electrical properties. The NFC has put in about four years of sustained effort to productionise this vital item for the electronics industry.

The Complex has supplied to ECIL about 30 types of anodes, covering all standard capacitance values for capacitors in voltage range of 6 to 35 volts for operation upto 85° C. It has supplied more than one million anodes in the past three years, thereby saving a considerable amount of foreign exchange.

## Trombay Groundnuts Thrive in Gujarat

*(Continued from page 3)*

mers on 1.5 and 2.0 ha respectively. Comparative yields of J-11 on the same farms were 30 and 37 quintals.

The high productivity of TG-17 attracted the attention of neighbouring farmers who wanted to cultivate it during the *kharif* season of 1977. As a result, more than 200 ha have been covered by TG variety in Gujarat. The standing TG-17 crop in the Bhavanagar district is distinctly superior. There is less leaf shedding due to *Tikka*, a leaf spot disease in this variety than in the J-11. It is therefore expected to give better yields.

Gujarat produces nearly 30 per cent of the total groundnut output of the country. More than 75 per cent of Gujarat's production comes from only five districts *viz.* Bhavanagar, Amreli, Rajkot, Junagadh and Jamnagar which constitute the groundnut bowl of India.

Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India
Chhatrapati Shivaji Maharaj Mar_, [illegible] 400 039, and printed by him at G. Claridge & Co. Ltd., Bombay 400 001

**Registered No. R. N. 9002/62**

NUCLEAR INDIA

VOL. 16 No. 3 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY NOVEMBER 1977

# *BARC-Built Gamma Irradiator for Indonesia*

THE Bhabha Atomic Research Centre is to supply and install, on a turn-key basis, a Panoramic Batch Irradiator (PANBIT) at the Pasar Jumat Research Centre of the National Atomic Energy Agency of Indonesia.

The irradiator, housing 75,000 curies of cobalt 60, would cost over Rs. 10 lakhs in foreign exchange.

The design and specifications of the irradiator were developed by the Isotope Group of the Centre, which will also be installing it. This unit will enable a range of process development activities with widely varying dose requirements. Among some of the uses to which it can be put are: radiation sterilisation of medical products, radiation polymerisation of impregnated wood, pasteurisation of fish, sprout inhibition in potatoes and onion, and other radiation-induced chemical reactions like oxidation, sulphochlorination, polymerisation etc.

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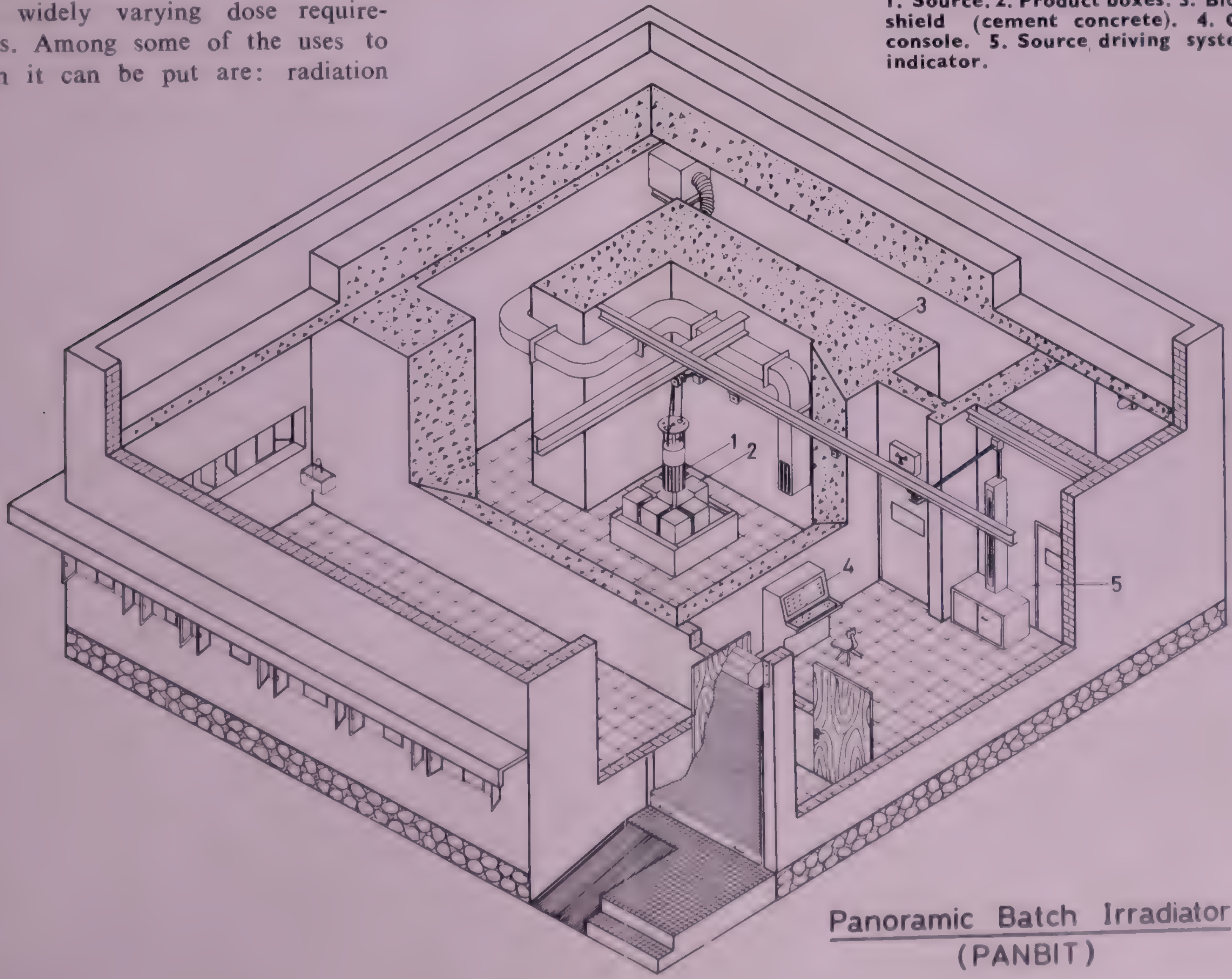
The source is shielded inside a lead flask which is housed in a pit under the floor of the cell. The source is also doubly encapsulated in seal welded stainless steel pencil to obviate any possibility of leakage; a remote controlled electro-mechanical lifting device, and a schuffle-dwell electro-pneumatic conveyor system ensures uniform dosage. The unit is provided with thick concrete shielding.

The Isotope Group has developed the complete know-how for many other types of irradiators, such as Gamma Chamber, Gamma Shine etc. suitable for a variety of uses. Several of these units have been installed at various centres in India. ●



**1. Source. 2. Product boxes. 3. Biological shield (cement concrete). 4. Control console. 5. Source driving system and indicator.**

Panoramic Batch Irradiator
(PANBIT)

# Geomagnetic Studies in India

**At Gulmarg in Kashmir, the Bhabha Atomic Research Centre operates a High Altitude Research Laboratory. In September this year a magnetic observatory was set up next to the laboratory by the Indian Institute of Geomagnetism as Gulmarg offers some special conditions for studying the effect of magnetospheric processes on the ionospheric current systems, and for geomagnetic survey work. The observatory includes special non-magnetic structures (for housing magnetic instruments) constructed by the Civil Engineering Division of BARC.**

A view of the High Altitude Research Laboratory campus at Gulmarg showing the non-magnetic Absolute Room of the observatory.

**by G. K. Rangarajan**
Indian Instt. of Geomagnetism, Bombay

THE science of geomagnetism may be considered to have taken roots with the discovery, several centuries ago, of the "directive" property of lodestone — a naturally occurring magnetic material. That the earth behaves like a big magnet has been known for a long time but significant insight into the intricacies of geomagnetic field variations is of recent origin, *i.e.* of the post-satellite era. Through an ingenious method, the method of spherical harmonic analysis, applied to the then scanty geomagnetic data, the German mathematician and astronomer Karl Friedrich Gauss (1777-1855) showed that the bulk of the earth's magnetic field emanates from within. A small but potentially significant fraction (about 1 to 5 per cent) has its origin outside the earth, with the sun as its main source. As it became known that the vast space between the sun and the earth is one huge laboratory freely available for studies on plasmas, launching of satellites with magnetic and other payloads was the next logical step. Information received from these satellites has only underlined the fact that physical theories in themselves are inadequate to explain all the observed geophysical phenomena. To test the validity of several postulates, and to provide reliable ground-based data, a network of magnetic observatories was conceived. Since geomagnetic variations spanning the entire range of frequencies exhibit a latitudinal dependence, it is necessary to have as dense a network of magnetic stations as possible.

India began systematic observation and study of the surface magnetic field almost a century back; it has one of the oldest magnetic observatories of the world located at Bombay-Alibag. To quote a report of the International Association of Geomagnetism and Aeronomy (IAGA):

"... the records of Colaba and Alibag were found to form a beautiful series beginning in 1871 and making up perhaps the most complete collection of records in the world, Their quality and, especially their regularity, were particularly impressive even in comparison with Kew and Melbourne records" (*P. N. Mayaud in Bull. No. 33 of the IAGA.*)

### Indian Magnetic Observatories

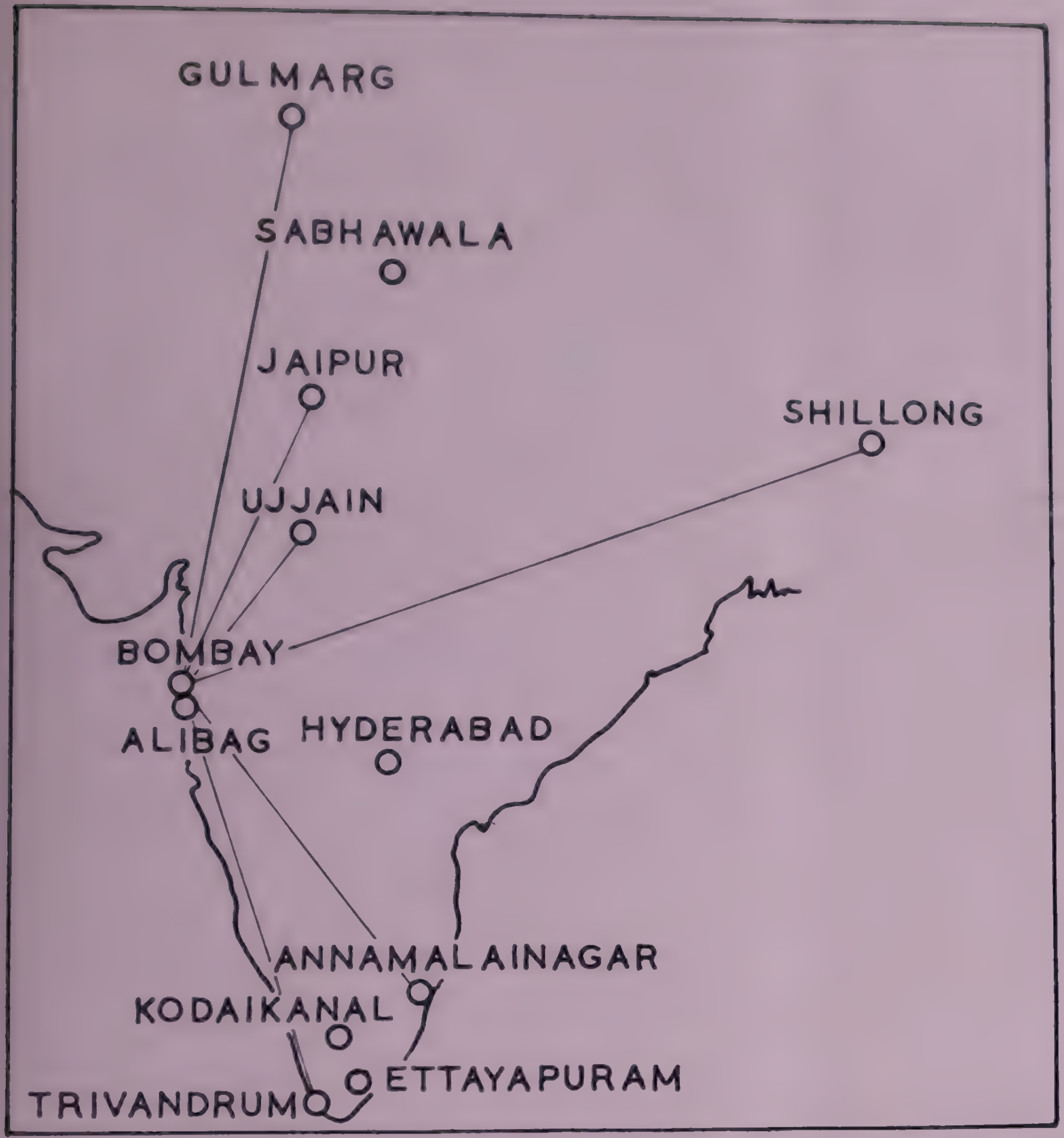
Starting with the establishment of the observatory at Colaba, Bombay in 1846, and ending with the commissioning of the Gulmarg observatory in 1977, there are now 11 magnetic stations, from Trivandrum in the south to Gulmarg in the north. A table showing the location of these observatories and other details is given on page 4.

India is one of the few countries where such a distribution in latitude of land is available. This aspect enables the study, in depth, of several interesting features associated with geomagnetic field variations at low and equatorial latitudes.

### Equatorial Electrojet

In the early part of this century a startling discovery was made: geomagnetic field variations in horizontal intensity were found to exhibit an anomalously large range over a small latitude zone centred on the dip equator. This was later known to be associated with the intense band of current flowing from west to east in the ionospheric E-layer called "The Equatorial Electrojet"; analogous to the "jet stream" in meteorology.

A look at the dip 'I' values listed in the Table shows that peninsular India is most favourably situated for a study of this phenomenon and its complexi-



**A map showing the location of all permanent magnetic observatories in India, with lines joining those run by the Indian Institute of Geomagnetism.**

ties. The magnetic data of the four Indian stations — Trivandrum, Ettayapuram, Kodaikanal and Annamalainagar, together with that of Alibag and Hyderabad have proved most useful in studies relating to:

(i) The nature and magnitude of the equatorial electrojet in the Indian region.

(ii) The question whether the electrojet current is a superposition over the world-wide Sq. currents, or a separate current system.

(iii) The cause and nature of the counter-electrojet phenomenon during periods of which the field at equatorial latitudes shows a depression instead of an enhancement.

(iv) The day-to-day variability and seasonal changes of the electrojet strength and its axis.

(v) The relation between the world-wide Sq. current, and the electrojet current.

(vi) The relation between the strength and direction of the electrojet and the interplanetary magnetic field.

### Electromagnetic Induction Within the Earth, and Coastal Effects

The magnetic observatories at Alibag, Trivandrum and Annamalainagar are located close to the coast. Together with the corresponding inland stations at Hyderabad, Ettayapuram or Kodaikanal, significant insight into the problems related to the modulation, by the ocean, of the surface daily variation in geomagnetic field, especially in the vertical component, can be obtained. These and other related studies enable scientists to construct models approximating the snb-surface conductivity distribution in the vicinity of the magnetic observatories, and provide valuable clues to geologists and geo-physicists in the exploitation of natural resources. The magnetic stations at Shillong and Sabhawala would likewise provide data for studies on the distribution of electrical conductivity and depth, to the mantle in the lesser Himalayan regions.

### Low-latitude transient variations, bayse, magnetic pulsations and other periodic oscillations

The latitudinal distribution of Indian magnetic stations provides valuable data in unravelling the complex behaviour of transient variations with periods ranging from about a year to a few seconds. Most of these variations have causative mechanisms located above the earth, preferentially in the ionosphere and the magnetosphere. The transformation processes that take place far above the earth, at distances of the order of a few earth radii can be surmised from the records of the magnetic field variation at low latitudes, and those close to the dip equator.

Ground-based monitoring of magnetic pulsations in the range of 2 to about 600 secs. gives extensive information useful in the diagnosis of both the day-side and night-side magnetosphere. The magnetic observatories at Ujjain and Jaipur were specially commissioned with a view to providing a uniform latitudinal distribution of magnetic stations, as a part of a multinational project — Project Geomagnetic Meridian. They are continuing to aid another major international venture, 'The International Magnetospheric Study', during which a comprehensive and unified picture of the outer environment of the earth is likely to emerge.

### Lunar magnetic variations

In comparison with the magnitude of the daily variation of the magnetic field associated with the Sun, the amplitudes of oscillations associated with the tidal effect of the moon are much smaller, but they can still be detected by statistical analysis. Such studies, carried out at the Institute, have provided valuable information regarding the

*(Continued on page 4)*

# Special Non-magnetic Lab Room at Gulmarg

(*Continued from page 3*)

seasonal changes, the dependence of the magnitude of the lunar daily variation on magnetic activity, solar activity, and the distance of the moon from the earth. The observed total variations can also be separated into a part attributed to the ocean currents and another to the ionospheric currents.

### Influence of Interplanetary Magnetic Field at Low Latitudes

The strong magnetic field on the Sun's photosphere is stretched out by the streaming plasma; this field, extending past the orbit of the earth, is known to provide the vital link in the energy transfer processes between the interplanetary medium and the magnetosphere. Magnetic data from the Indian chain of observatories have been extensively used in studies related to the influence of the direction, in the ecliptic plane of the Inter-planetary Magnetic Field (IMF), defining the sector structure of the field. Significant correlation between the passage of the boundaries of the sector structure and low latitude geomagnetic field, indices of magnetic activity, and occurrence of magnetic pulsations in different frequency ranges have been established. Association between lunar daily variation and the sector structure of IMF has also been indicated in some studies.

**The 3 La Cour variometers installed at Gulmarg to record variations in H, Z and D.**

**Table**

| Station | Geographic | | Dipole | | Functioning from | Organisation* | Approximate values of | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Lat. | Long. | Lat. | Long. | | | D | I | H | Z |
| | | | | | | | | | nT | nT |
| Gulmarg .. .. .. .. | 34°03′ N | 74°24′ E | 24°.5 N | 147°.2 | 1977 | IIG | 1°30′ E | 51°.0 | 31000 | 40050@ |
| Sabhawala .. .. .. | 30°22′ N | 77°48′ E | 20°.8 N | 149°.8 | 1964 | SOI | 0°22′ E | 45°.0 | 34050 | 34400 |
| Jaipur .. .. .. .. | 26°55′ N | 75°48′ E | 17°.3 N | 147°.4 | 1975 | IIG | 0°50′ W | 40°.0 | 36000 | 29600 |
| Shillong .. .. .. .. | 25°34′ N | 91°53′ E | 14°.6 N | 162°.4 | 1975 | IIG | 0°42′ W | 35°.0 | 37700 | 27200 |
| Ujjain .. .. .. .. | 23°11′ N | 75°47′ E | 13°.5 N | 147°.0 | 1975 | IIG | 0°32′ W | 33°.0 | 37300 | 24250 |
| Alibag .. .. .. .. | 18°38′ N | 72°52′ E | 9°.5 N | 143°.6 | 1904 | IIG | 0°50′ W | 24°.0 | 38500 | 17400 |
| Hyderabad .. .. .. | 17°25′ N | 78°33′ E | 7°.6 N | 148°.9 | 1965 | NGRI | 1°38′ W | 20°.0 | 39900 | 14900 |
| Annamalainagar .. .. .. | 11°22′ N | 79°41′ E | 1°.4 N | 149°.4 | 1957 | IIG | 2°40′ W | 5°.5 | 40500 | 3900 |
| Kodaikanal .. .. .. | 10°14′ N | 77°28′ E | 0°.6 N | 147°.1 | 1949 | IIA | 2°25′ W | 3°.0 | 39350 | 2150 |
| Ettayapuram .. .. .. | 9°10′ N | 78°01′ E | 0°.6 S | 147°.5 | 1975 | NGRI | 2°54′ W | 0°.5 | 40300 | 300@ |
| Trivandrum .. .. .. | 8°29′ N | 76°57′ E | 1°.2 S | 146°.4 | 1957 | IIG | 2°45′ W | —1°.0 | 39950 | —600 |

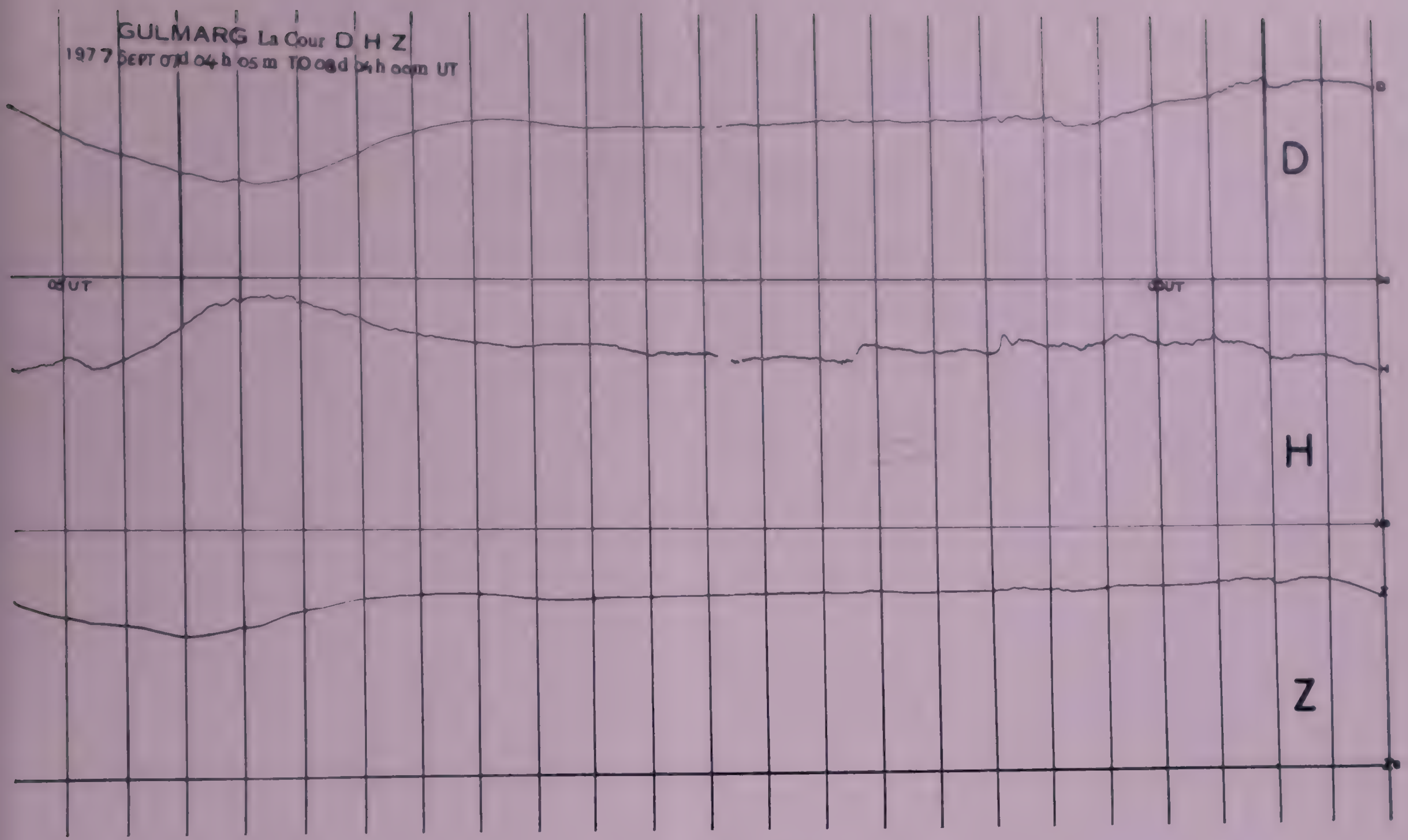
*IIG : Indian Institute of Geomagnetism, Colaba, Bombay.

IIA : Indian Institute of Astrophysics, Kodaikanal.

NGRI : National Geophysical Research Institute, Hyderabad.

SOI : Geodetic & Research Branch, Survey of India, Dehra Dun, U.P.

@ Values derived from model global field.



**A typical magnetogram showing 24 hours' geomagnetic variations at Gulmarg.**

**Gulmarg Magnetic Observatory**

To analyse the problem related to day-to-day variability of the geomagnetic field variations, and to determine the association between the Sq. current and the equatorial electrojet currents, it is essential that a magnetic station be maintained in the vicinity of the focal latitude, and in the same longitude zone as other stations above and below. The magnetic station at Sabhawala has been serving this purpose, but the latitudinal gap between Sabhawala and the next higher latitude station, Tashkent in the USSR, is quite appreciable and the focal latitude is found to be located between the two in this longitude belt. A station located close to the latitude of the focus can also be used to study the effect of magnetospheric processes on the ionospheric current systems. Also, for geomagnetic survey work in the country, a suitably located base station in relation to which the field data can be reduced is essential.

In view of these long felt needs, the Indian Institute of Geomagnetism decided to establish a permanent magnetic observatory in Jammu and Kashmir region and availed of the offer of land and facilities made by the Bhabha Atomic Research Centre at its High Altitude Research Laboratory in Gulmarg. Two structures, entirely non-magnetic in nature and specially constructed to house the magnetic instruments, were built by the Civil Engineering Division of BARC. The Gulmarg Magnetic Observatory became operational in September 1977.

The present set-up at the Magnetic Station at Gulmarg consists of:

1. A La-Cour three-component variometer system with a photographic recorder, registering variations in the three components, H, Z and D of the earth's magnetic field at a uniform char-speed of 20 mm/hour. This uniform speed is achieved through a synchronous motor (230 V AC/50 Hz), for which power is derived from a 12V DC source, and an inverter.

2. A system for time marking on the magnetogram to indicate exactly the beginning of each UT hour. This is recorded by flooding the cylindrical lens in front of the recorder for a duration of about 5 seconds by a light source which is switched on at each UT hour. The timer used is a high precision digital clock. Accurate time is derived from a 1 MHz quartz crystal, and a frequency count-down chain using divider counter ICs, which divides this frequency to 1 second and 1 hour timed output.

3. Calibration systems for the variometers, which are Helmholtz coils with single turn of wire, with the magnets of the three different systems at the appropriate centres of the coils through which known current can be passed, creating a given magnetic field at coil centre.

4. A Quartz Horizontal Magnetometer (Q.H.M. No. 734), which is used for measuring the absolute value of the horizontal component daily, and the absolute value of Declination once a week.

5. A Balance Magnetometer Zero (B.M.Z. No. 304), which is used for

*(Continued on page 8)*

*Exploiting Low Grade Ores*

# Work at the Ore Dressing Section of the BARC

**by G. V. U. Rao**

Head, Ore Dressing Section
Bhabha Atomic Research Centre

MODERN civilisation is largely dependent on minerals and mineral products. With increasing industrialisation therefore there is a continuing rise in the quantity and variety of minerals consumed. Consequent upon this, high grade ores are getting depleted at an alarming rate. Since ores are unreplenishable and wasting assets, all countries are obliged to treat progressively lower grade ores.

Low grade ores however cannot be used economically for extraction of their metal values without some pretreatment, known as "ore-dressing" or "mineral-dressing." Through mineral dressing operations, valuable minerals are separated from the ores as concentrates, and the gangue* minerals are discarded as tailings.

The first step in this beneficiation process is "comminution"—crushing and grinding, whereby the ore minerals are liberated from the gangue minerals. This ground material is then subjected to one or more physical processes like gravity separation, magnetic separation, or high-tension separation, depending upon the property of the mineral which is to be exploited for effective separation.

Another well-known process of concentration is flotation, which is based on the physico-chemical property of the surface of mineral particles. In this process, small quantities of certain reagents are added to the slurry consisting of mineral particles and water. These reagents selectively coat the desired minerals and make them non-wettable. When air is introduced into such a pulp, the reagent-coated mineral particles attach themselves to the air bubbles and float to the surface from where they are skimmed off. This process finds extensive use in the concentration of sulphide minerals, particularly of base metals.

At the Bhabha Atomic Research Centre, an Ore Dressing Section works on development of flowsheets for treatment of low-grade ores, containing Uranium (U), Thorium (Th), Beryllium (Be), Wolfram (W), Lithium (Li), Niobium (Nb), Tantalum (Ta), Titanium (Ti), Zirconium (Zr), Lead (Pb), Copper (Cu), Zinc (Zn), Arsenic (As), Antimony (Sb) etc.

In the early sixties, BARC paid considerable attention to the recovery of all the economic minerals—ilmenite, monazite, rutile, zircon, sillimanite—present in the beach sand deposits of the west coast of India. Prior to this, only ilmenite was being produced on a commercial scale. The BARC has developed a flow sheet for successfully recovering all the above minerals and has transferred the know-how to Indian Rare Earths Ltd. (IRE), a public sector undertaking of the Dept. of Atomic Energy. Based on this flow sheet, the IRE is now producing annually approx. 2,80,000 tonnes of ilmenite, 3,000 tonnes of monazite, 14,000 tonnes of rutile, and 13,000 tonnes of zircon.

### Byproduct Recovery Plant

In some cases small quantities of valuable minerals may be associated with the main ore mineral which is the primary target of investigations. Efforts have therefore been made to recover these valuable minerals present in small amounts as byproducts with marginally extra investment. This may be illustrated by the following case history: The uranium mill of the Uranium Corporation of India (UCIL) at Jaduguda in Bihar has been producing magnesium diuranate (MDU) for several years. The Ore Dressing Section's investigations have shown that this uranium ore contains, on an average, 0.026 per cent Mo, 0.08 per cent Cu and 0.09 per cent Ni in the form of sulphide minerals. Batch scale testing and pilot plant testing was carried out to recover these minerals by flotation, and a project report prepared, including necessary equipment, plant layout, manpower and services requirements. Based on the flowsheet recommended by the Section, this Byproduct Recovery Plant has been operating for about 2 years. It is capable of producing annually 78 tonnes of molybdenite concentrate, 420 tonnes of chalcopyrite concentrate, and 1200 tonnes of pentlandite/millerite concentrate analysing 45.8 per cent Mo, 20 per cent Cu and 5 per cent Ni respectively. It may be mentioned here that this is the first plant in India producing molybdenite, a mineral which is in great demand in the steel industry.

It is known that copper ores from the Singhbhum Shear Zone are uraniferous. The tailings discharged from the copper ore treatment plants contain approx. 0.01 per cent $U_3O_8$. The Section has investigated the possibility of recovering the uraninite present in these tailings, and has recommended a flowsheet for the purpose. Based on this flowsheet, UCIL has erected a plant on the south bank of Suvarnarekha river to treat 360 TPD of the tailings from the Surda Copper concentrator. The concentrate; produced by this byproduct plant assays 0.12 per cent $U_3O_8$. The plant can yield approx. 11 tonnes of $U_3O_8$ per annum relatively cheaply.

Similar studies have been carried out on Rakha copper ore and a flow sheet for recovering the copper and uranium minerals has been prepared. When fully operational, the Rakha plant is expected to treat about 4,000 TPD; the tailings from this plant are capable of yielding 48 tonnes of $U_3O_8$ per annum. Though the tonnage of $U_3O_8$ produced annually is not very large in view of the extremely low grade (0.01 per cent of $U_3O_8$ in the feed), the cost of production is much less since it is a by-

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*Portion of ore which contains no mineral.

# *BARC's Multi-Disciplinary Structure Helps in Mineral Dressing Work*

product, and scarce uranium is also conserved.

The ore-dressing equipment industry in India is in its infancy and has therefore been unable to supply pneumatic flotation cells and Deister type wet concentrating tables for the ore-dressing plants mentioned earlier. The BARC therefore had to provide technical guidance for fabrication of the first prototype equipment. Based on this unit, other units were manufactured for use in the aforesaid plants. The Ore-Dressing Section has also fabricated pneumatic table, multiple-hearth furnace, pneumatic pre-concentrator, radiometric sorter and automatic band-splitter for use in wet tabling of radioactive ores.

The expertise and know-how generated at BARC for beneficiation of a large variety of ores have been made available to the Departments of Mines & Geology of many State Governments, and several public-sector corporations like Hindustan Zinc Ltd., Hindustan Copper Ltd., Engineers India Ltd. etc. The BARC has attended to problems in mineral dressing referred to it by these organisations and has also successfully developed flowsheets for the treatment of ores containing As, Cu, Pb, Zn, Ni, Mo, Sb, W, Nb, Ta, Li, besides graphite and phosphorite.

The success of such diversified efforts depends on strong supporting facilities in the areas of mineralogical analysis, chemical analysis and radiometric analysis wherever necessary, of feed material and mill products. These infrastructural facilities have been gradually built up at the BARC over the years. It has therefore been possible for BARC to draw upon its multi-disciplinary structure to attend to any mineral-dressing problem.

### Research & Development Work

In addition to the applied investigation works, the Ore Dressing Section has carried out fundamental research in the fields of (i) Surface Chemistry related to mineral dressing, and (ii) Petrology.

*Surface Chemistry*: Studies on the changes in surface characteristics of minerals by the adsorption of collectors and regulators have been carried out with a view to optimising the conditions for selective flotation of many economic minerals from the associated gangue minerals. The complex nature of the different interfaces involved in flotation is also studied by (a) electrode potential and adsorption studies of the reactions taking place at the solid-liquid interface, (b) zetapotential studies to study the surface changes on minerals, (c) contact angle and Kassel's three phase contact perimeter studies for the solid-liquid-air interface, and (d) infra-red adsorption studies to identify the reaction products present on the mineral surface.

*Petrology* : The Section has investigated the petrochemistry, geochemistry and geochronology of the Mundwara Igneous Complex and associated carbonatites of the Sirohi District of Rajasthan, and the uranium and copper ores of the Singhbhum Shear Zone. Fission-track dating of a constituent of the Mundwara Carbonatite has indicated that its age is $56 \pm 8$ million years, *i.e.* it is contemporaneous with the uppermost Deccan Traps, contrary to the popularly held belief that its age is post Erinpura but pre-Malani (between 725 and 600 million years), based on mineralogical similarities.

Detailed mineralogical, petrological and geochemical studies of uranium and copper ores from the Singhbhum Shear Zone, have brought to light 5 new minerals hitherto unreported from this area, and have also indicated that the uranium in this zone is remobilized. A revised sequence of metallogenesis, and a time frame for the same has been proposed.

Obviously, mineral dressing has an increasingly important role to play in the exploitation of low grade ores containing, inter alia, Be, Li, Nb, Ta, W, Ti and Th which are in great demand in work relating to Atomic Energy, Space and Electronics. ●

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# Protection of Nuclear Materials

REPRESENTATIVES of 40 governments met recently at the headquarters of the International Atomic Energy Agency (IAEA) in Vienna to consider the drafting of a convention on the physical protection of nuclear material.

The first draft of such a convention was prepared by the United States Government. In June this year the IAEA circulated it to all member-States of the Agency.

The General Conference of the IAEA, meeting in September, adopted a resolution which urged the Director-General and member-States to facilitate the development of an appropriate international agreement for adoption by as many States as possible.

This meeting is likely to be the first of several meetings intended to prepare a final and internationally accepted text of an agreement. It is hoped that this work can be completed by September next year and that the agreement can then be opened for signature by Governments.

The present draft agreement deals with problems of protecting nuclear material (generally uranium and plutonium) in international transport, and with some national problems of physical protection.

The main provisions of the draft would require co-operation between States in recovering lost or stolen nuclear material and in protecting such material when it is being transported and stored.

Certain activities would be classified internationally as crimes and States would undertake either to prosecute those crimes themselves or extradite the alleged offenders. ●

# Neutrons Against Cancer

THE Cancer Therapy Facility at Fermilab treated its first patient a year ago (7 September 1976). Since then a total of 86 patients have completed the prescribed course of radiation and, overall, the results have been very satisfactory.

The Facility draws a neutron beam from a beryllium target bombarded by 66 MeV protons from the linac of the 500 GeV synchrotron. It has been used for biomedical experiments, as well as for cancer treatment, mainly aiming to determine parameters of neutron radiation which are important for therapy and for comparisons with other forms of radiation.

With the patients treated so far, the use of neutron beams as the sole method of treatment was very successful in controlling radiation resistant tumours. Side effects have been mild.

* * *

THE Medical Research Council Cyclotron Unit at Western General Hospital, Edinburgh was officially opened on 27 September. It houses a cyclotron for the production of neutron beams for cancer treatment.

Two neutron beams are produced by the cyclotron and a special feature is that one of them is steerable. The compact cyclotron, manufactured by the Cyclotron Corporation, provides 100 µA of deuterons at 15 MeV. A switching magnet enables the output beam to be directed onto a fixed target or an isocentric target to give the manoeuvrable beam.

The considerable clinical experience in the use of neutron beams for cancer therapy at the Hammersmith Hospital, London, was of great value in the design of the new unit. The first patients were treated in March of this year and some 70 patients have now completed their treatment. All have received neutrons from the fixed beam up to now and the steerable beam is scheduled to be in operation in a few months' time.

A TEAM of biologists (Frank Ngo, Antun Han, Hiroshi Utsumi and Mortimer Elkind) from the Biological and Medical Research Division at Argonne are carrying out a detailed study of the relative effects of neutron irradiation and conventional X-ray and cobalt-60 gamma rays on cancerous cells.

They have access to three neutron sources in the Chicago area, each covering a different energy spectrum. These are—the JANUS reactor at Argonne, the cyclotron at the Franklin McLean Institute of Chicago University and the Cancer Therapy Facility at Fermilab.

The results so far show that smaller doses of neutrons than X-rays are needed to kill equal numbers of cells. As the neutron energy increases (from reactor energies to CTF energies) the dose needed increases. Neutrons are more effective in killing the oxygen starved, radiation resistant cells often found in tumours. Also, the cells are less able to repair damage after neutron irradiation. (*CERN Courier, Oct. 77*)

# Decommissioning of Nuclear Facilities

A COMMITTEE of technical experts from 10 countries and two international organisations met in Vienna in October to review the decontamination and decommissioning of nuclear facilities for their safe disposition after their operational lives. The meeting was convened by the International Atomic Energy Agency (IAEA).

The purpose of the meeting was to initiate the development of a code of practice and guidelines to the code for the decommissioning of nuclear reactors. Among the topics reviewed by the technical committee were the radiological, mechanical and administrative aspects of decommissioning. The committee endorsed the conclusions of its prior meeting in 1975 on the same subject that there were no insurmountable technical problems to decommissioning of nuclear reactor after their operating lives. In addition the committee discussed the decontamination requirements of facilities t be decommissioned.

The technical committee also discussed the subjects to be covered at th International Symposium on the Deco missioning of Nuclear Facilities whic is to be held in Vienna from 13 to 1 November 1978. The Symposium i being sponsored by the IAEA and th Nuclear Energy Agency of the Orgar isation for Economic Co-operatio and Development. ●

# *Gulmarg Station*

(*Continued from page 5*)

determining the absolute value of the vertical component of the earth's field. A proton vector magnetometer for precise determination of horizontal component and derivation of the vertical component from the value of the total field will be commissioned shortly.

While the variometers are set up in a thermally insulated double-walled, light-proof structure, the absolute measurements are carried out in an adjacent non-magnetic room. The photographic paper registering the field variation is changed every day and developed. The calibration experiments are carried out once a week, and the magnetograms and other data are sent to the Indian Institute of Geomagnetism at Colaba, Bombay in weekly batches for further processing.

In view of the importance of the location of the Gulmarg magnetic station, the data and records obtained will prove to be of immense use to scientists everywhere. Collaborative research programmes between scientists at the Nuclear Research Laboratory at Srinagar and at the IIG are also on the anvil.

The role played by BARC in assisting IIG in establishing this magnetic station cannot be over-emphasised. A word of thanks is also due to the Survey of India for quickly evaluating the azimuth of the datum mark used in computation of the absolute value of Declination. ●

Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India
Chhatrapati Shivaji Maharaj Marg, Bombay 400 039, and printed by him at G. Claridge & Co. Ltd., Bombay 400 001.

Registered No. R. N. 9002/62

NUCLEAR INDIA

VOL. 16 No. 4 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY DECEMBER 1977

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*Exploiting Monazite Sands*

# Indian Rare Earths' Impressive Performance

**The formation and growth of the Indian Rare Earths Ltd., one of the three public sector undertakings of the Department of Atomic Energy is closely linked with the development of atomic energy in India. The Company came into existence due to the efforts of the late Dr. Homi Bhabha who also guided its activities in its early stages. From a small beginning in 1950, the IRE has grown to a position where it has become the supplier of one-third of the world's requirements of rare earths. Shri N. D. HANSOTIA, the Managing Director of the Company reviews its growth and achievements during these 25 years. The Company is celebrating the Silver Jubilee of its Rare Earths Plant on December 27.**

THE beach sands of the south western coastal regions of India are rich in monazite, a mineral which is among the major sources of thorium, and also contains the rare earth elements, particularly cerium and lanthanum. Chemically processed, monazite provides a wide range of industrial chemicals such as rare earths chloride, rare earths fluoride, rare earths oxide, trisodium phosphate and also pure compounds of individual rare earths like cerium, lanthanum etc., besides thorium hydroxide from which thorium is extracted. These products find extensive applications in industries concerned with textiles, sugar, detergents, petro-chemicals, optical glass, television tubes, carbon electrodes, etc.

Till 1948, this abundant source of mineral riches was finding its way out of India. But things changed with the formation of the Atomic Energy Commission in August that year: among the first steps taken by it was to urge the Government of India to ban the export of monazite. The Commission decided to process the sands and manage the rare earths export industry.

In August 1950, the Indian Rare Earths Ltd. was set up to manage all matters connected with monazite processing and related industrial activities. It was registered as a private limited Government company at Bombay with an authorised capital of Rs. 1 crore of which 55 per cent was subscribed by the Government of India, and the rest by the then Government of Travancore-Cochin. The State Government's shares were later taken over by the Government of India, making the Company a full-fledged Central Government undertaking. The Indian Rare Earths Ltd. is today one of the three public sector undertakings of the Department of Atomic Energy.

In the latter half of 1952, IRE's first chemical plant—a rare earths plant at Eloor near Alwaye, commenced production. It was built in a record time of 12 months in technical collaboration with a French firm. The plant was formally inaugurated by the then Prime Minister, Pt. Jawaharlal Nehru on December 24, 1952.

The Company also played an important role in the establishment of the various facilities at the Bhabha Atomic Research Centre (then the Atomic Energy Establishment, Trombay) in its early stages of development. In the late fifties and early sixties, the IRE assisted in building the Thorium Plant, the *Apsara* reactor, the Uranium Metal Plant, the Fuel Element Fabrication Facility, the CIRUS reactor and certain other units. The Company also constructed the Uranium Mill and some other facilities at Jaduguda, Bihar for the Uranium Corporation of India, a sister undertaking.

The IRE has its headquarters in Bombay. It controls four divisions: the Rare Earths Division, with its local office at Alwaye; the Minerals Division, with its local office at Quilon; the Thorium Plant at Trombay, Bombay, which the Company operates on behalf of the Department of Atomic Energy, and the Orissa Sands Complex (OSCOM) at Chatrapur in the Ganjam District of Orissa.

## *Rare Earths*

The Company's Rare Earths Division manages the Rare Earths Plant.

There is also a pilot plant built by the Company for the recovery of helium. This inert gas is obtained as a by-product in monazite processing and is in great demand in the nuclear industry.

## *Mineral Sands*

The mineral sands industry, located at Manavalakurichi in Tamil Nadu, and at Chavara in Kerala, which was under the control of foreign companies for nearly three decades, came under State control soon after Independence. In 1965, the IRE took over the beach sands separation plants at Manavalakurichi and Chavara from the Travancore Minerals Ltd. (which went into voluntary liquidation). The

(*Continued on page 8*)

## Radiation Protection

(*Continued from page 7*)

instruments needed for radiation dosimetry purposes. In addition, the Group fabricates demonstration units and experimental systems for the trainees of different courses conducted by the Division.

### Radiation Standards

The Radiation Standards Laboratory of the Division maintains primary standards for exposure and absorbed doses of X and gamma, and particulate radiation. Radiotheraphy centres in the country get their secondary standard dosimeters calibrated periodically against these primary standards. International intercomparison of these primary standards have also been conducted with other standard laboratories in the world. This laboratory has been designated a Regional Reference Centre for secondary standard dosimetry laboratory programme by the IAEA/WHO for receiving radiation measuring instruments for calibration from neighbouring countries.

### Research and Development

Research and development work related to thermoluminescence dosimetry phosphors, including production of phosphors and the development of personnel monitoring system for the countrywide use of TLD is being undertaken in the Division. Methods for preparation of a few standard phosphors have been perfected. The response of the phosphors to various types of ionising radiations are being investigated.

The High Level Dosimetry Group of the Division has developed a chemical dosimetric system to cover doses ranging from a few rads to a million rads. Such dosimetric systems are of great value in food irradiation, industrial irradiation and radiation sterilisation projects.

Dosimetry is also carried out to cover higher levels of doses encountered under accidental conditions. ●

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# The Fast Breeder

INDIA has a modest nuclear power programme, a major constraint on its enlargement being the very limited resources of uranium at its disposal. This inadequacy is however made up by the abundance of thorium ($Th^{232}$), a potential source of nuclear energy. Thorium is not a fissile element but it can be converted to uranium-233 ($U^{233}$) which, like uranium-235 ($U^{235}$), is fissile. There are three isotopes of uranium : the non-fissile uranium-238 ($U^{238}$), and the fissile uranium-235 and uranium-233. Natural uranium contains mostly $U^{238}$ plus a small quantity (0.7 per cent) of $U^{235}$ which is mostly exploited in reactors using natural uranium as fuel. There are also reactors using enriched uranium, which has a larger percentage of $U^{235}$. $U^{233}$ does not exist in nature ; it has so far been extracted in laboratories by chemical means.

At present India has one enriched uranium fuelled atomic power station —the 420 MW Tarapur Atomic Power Station, with two reactors of 210 MW each. Enriched uranium is supplied by the USA in the form of uranium hexafluoride which is made into fuel elements by the Nuclear Fuel Complex at Hyderabad. The process of enriching uranium involves high technology, is very expensive, and a high consumer of power. As such, India opted for the Pressurised Heavy Water (PHW)-type of reactors using natural uranium. These reactors also produce some plutonium ($Pu^{239}$), a very fissile element capable of being used as fuel. The power stations at Rajasthan, Kalpakkam and Narora have reactors of this type.

The PHW reactor converts $U^{238}$ to $Pu^{239}$ with high efficiency but does not produce enough of it to make up for the $U^{235}$ consumed.

All the present-day commercial nuclear power installations in the world have "thermal" neutron reactors. The reactors operating in India are also of the thermal type. The term "thermal" is employed because the reactors use moderators to slow down the high velocity neutrons produced in the fission process to low energies comparable to the thermal vibration energies of the moderator atoms. The fuel for these thermal reactors consists mostly of the isotope $U^{238}$ which is not readily fissionable. But whether the reactors use natural uranium or slightly enriched uranium, it is only the fissile component $U^{235}$ that is essentially "burnt" in them. Thus thermal reactors use only about 1 per cent of the available uranium fuel for generating power.

## The Three Stages

Uranium is mined in India
Jaduguda in Bihar. The Nuclear
Complex at Hyderabad processes
ral uranium into the nuclear fue
ments required for these reac
Because of the country's polic
working towards attaining a
degree of self-reliance, it has
thorium as the ultimate nuclear
in its long-range nuclear power
gramme.

India's nuclear power str
has been conceived to move in
stages. The first stage consists of
mic power stations fuelled by na
uranium. These reactors also pro
plutonium incidentally. This is

In the fast reactors, neutrons are not permitted to slow down; instead, the chain reaction is carried on by fast neutrons and almost all the mined uranium is burnt, thereby increasing the energy value of a given stock of uranium by over 60 times. This efficiency comes about because fast reactors have the unique property of replenishing the fissile fuel consumed by them in the course of operation. Indeed, they even produce some excess fuel which can be drawn off for use in other reactors. Hence their title "breeder reactors". Breeders need a net feed only of a fertile material such as $U^{238}$ or $Th^{232}$, the initial inventory of fissile fuel being required only at the time of commissioning of the reactor.

The technology involved in a fast reactor is of a highly advanced nature. The heart of the reactor is of course

# dia's Nuclear Programme

its core where fission occurs. A fast reactor core is characterised by high neutron fluxes and a high power density. The high energies of the neutrons (~100Kev), and the very high temperature in the reactor, as well as the special design requirements of the fuel pins, and the core configuration etc., demand fuel and structural material which can withstand the severe environment without wear. Work on the fast reactors therefore is all-comprehensive; it envelopes work on fuel, coolants and heat transfer agents, as well as the special metals and alloys that go into making the reactor components.

e in which the programme is
y. The plutonium accumulated
n these reactors will be used in the
nd generation reactors to convert
ium (placed as a blanket), into
, besides generating power.
second generation reactors will
convert depleted uranium from
first generation reactors into pluto-
n which will again go into converting
ium into $U^{233}$. The $U^{233}$ would
lly be burnt in the third genera-
reactors consisting of both fast
eders and thermal 'near bree-
' which would be optimised to run
he $Th^{232}$—$U^{233}$ cycle. This will be
thorium cycle stage, exclusively.

The coolant used for heat transfer has to have very high heat absorption properties. In most fast reactors liquid sodium in the core transfers the heat to a secondary loop of liquid sodium which in turn is used to convert water into steam.

In 1971, the Atomic Energy Commission set up a Reactor Research Centre (RRC) at Kalpakkam, near Madras, for work relating to fast breeder technology in all its aspects. A Fast Breeder Test Reactor (FBTR) is being built at the Centre with the assistance of France. The reactor is being designed on the same lines as the Rapsodie-Fortissimo reactor in France, but unlike it, the Kalpakkam reactor will generate approximately 14 MW of electric power.

The reactor is of the most advanced type and involves complex technology; its construction is being handled largely by Indian personnel, and most of the fuel, control instrumentation and components are being made in India. To a certain extent raw materials are being imported as they are not available in the country.

In addition to R & D work in applied areas like nuclear engineering, fuel development, fuel reprocessing, development of clad and structural materials etc. the Centre will support basic research in related fields such as radiation damage, chemistry of transuranium elements, behaviour of molten salts, physics and chemistry of liquid metals etc.

The experience acquired in the design, construction and operation of this reactor would help in the design of future fast breeder power stations in India. The FBTR would also serve as a test bed for the various fast reactor components being manufactured for the first time in the country. ●

### How Fuel Is "Bred"?

How is fresh fissile fuel 'bred' in a nuclear reactor? The fertile isotope $U^{238}$ present in the fuel elements, on absorption of a neutron, gets converted to $Pu^{239}$ through a couple of steps of nuclear transmutation. $Pu^{239}$ is a fissile material which is even better than the naturally found fissile isotope $U^{235}$, particularly for fast reactors. This *in situ* conversion of $U^{238}$ into $Pu^{239}$ takes place during its operation in both thermal and fast reactors.

Thorium, on absorption of a neutron in a reactor, becomes a new fissile isotope, $U^{233}$. The $Th^{232}$-$U^{233}$ fuel cycle is of special relevance to India's nuclear power programme since this country has the largest deposits of thorium in the world.

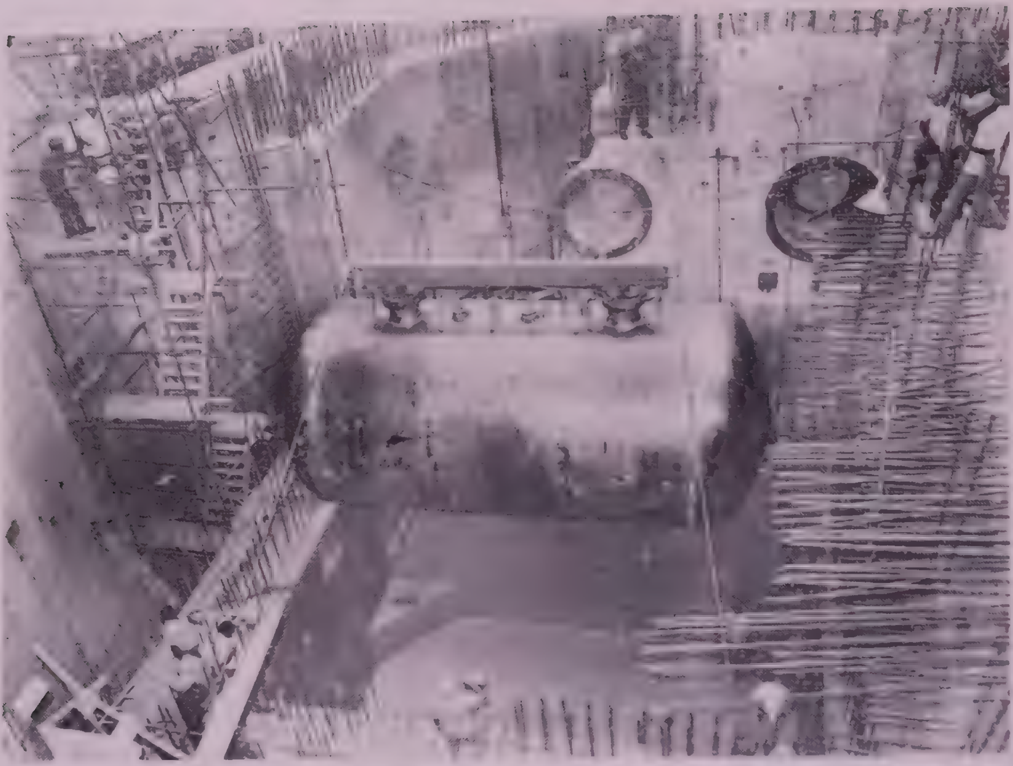
Several countries have graduated to fairly large scale fast breeder power stations. The PHOENIX station in France has had an excellent record of operation, amply fulfilling the hopes pinned on large fast reactors.

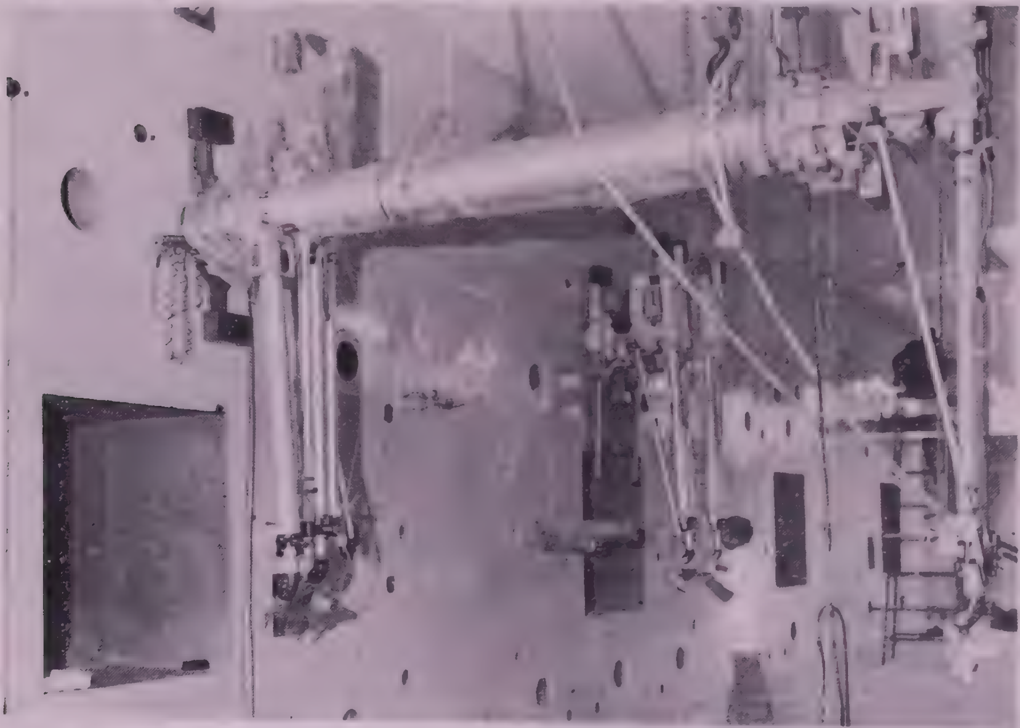
**Some of the medium-sized fast reactors which were/are in operation**

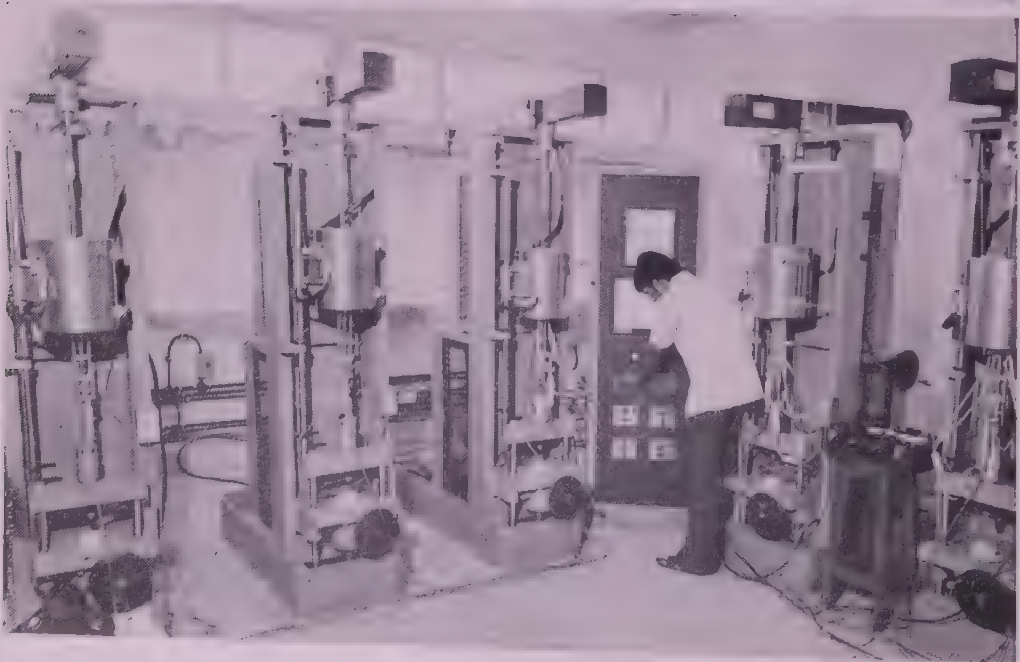
| Reactor | Country | MW(th) | MW(e) |
|---|---|---|---|
| EBR II | United States | 62 | 20 |
| Fermi (no longer in operation). | United States | 200 | 67 |
| Rapsodie | France | 40 | — |
| BR-60 | USSR | 60 | 12 |
| BN-350 | USSR | 1000 | 350 |
| Phoenix | France | 600 | 250 |
| JOYO | Japan | 100 | — |
| PFR | United Kingdom | 600 | 250 |

**Fast reactors under construction**

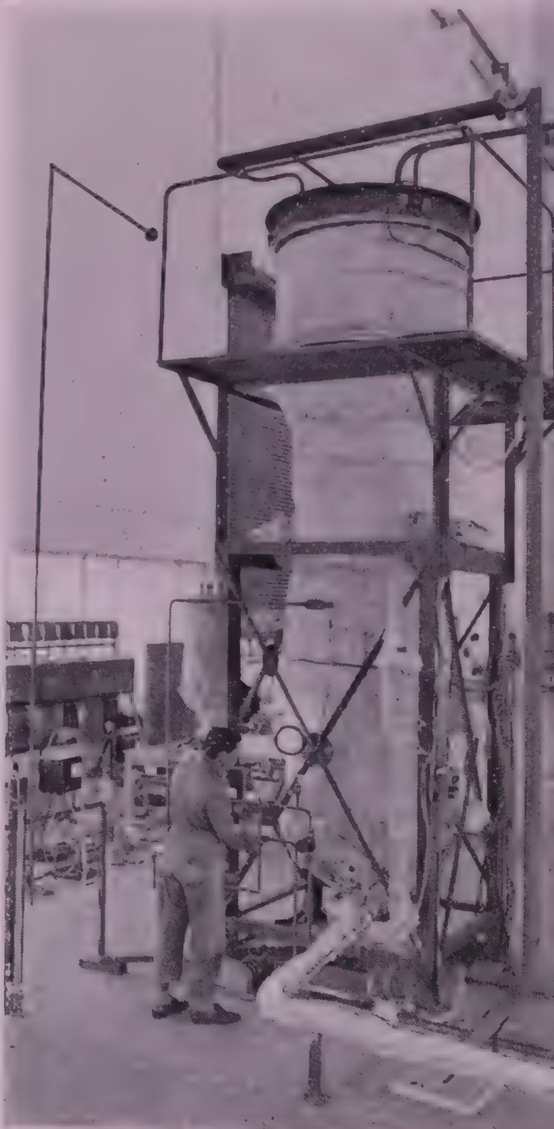
| Reactor | Country | MW(t) | MW(e) |
|---|---|---|---|
| FBTR | India | 42.5 | 12.5 |
| SNR-300 | Debenelux | 730 | 300 |
| FFTF | United States | 400 | — |
| MONJU | Japan | 714 | 300 |
| BN-600 | USSR | 1500 | 600 |



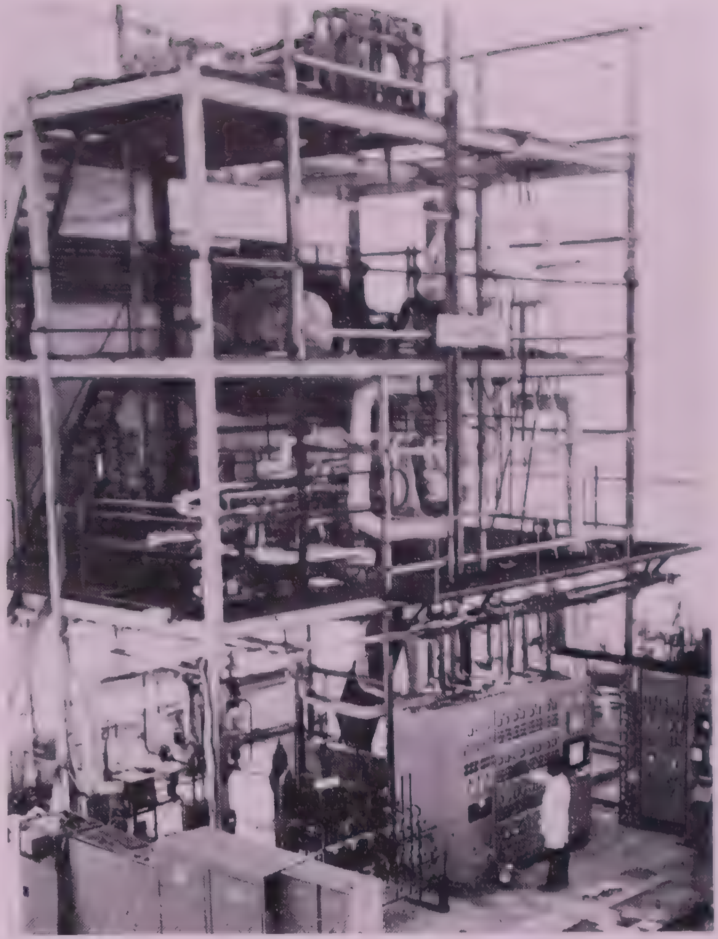




*Above* : **Fast Breeder Test Reactor building c**
**reactor building. Liquid sodium will be use**
**perties liquid sodium finds use as a coolant i**
**ing development laboratory.** *Left,* **bottom :**



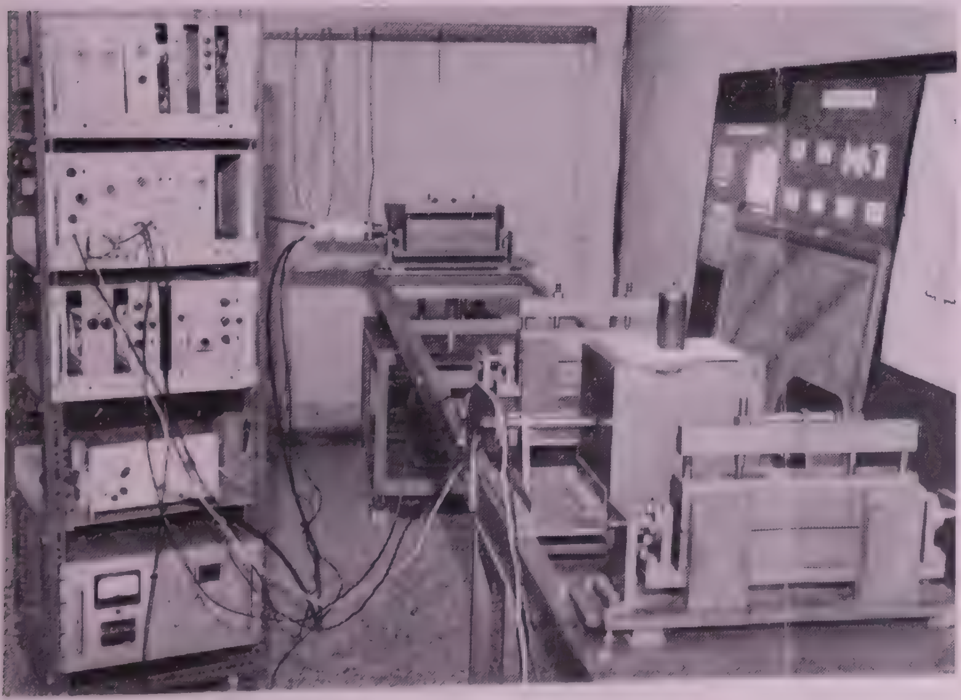
: **Storage tank for liquid sodium being lowered into a vault of the**
**water into steam. Because of its very high heat absorption pro-**
**actors in the world.** *Left, centre* **: Some hot cells of the reprocess-**
**e creep testing laboratory.**

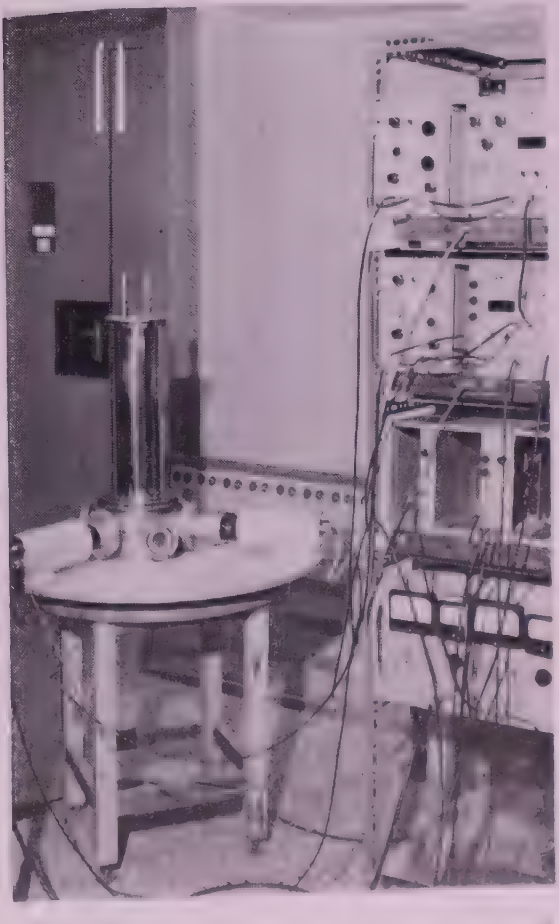


*Above* **: A 500 KW sodium loop being installed.** Below **: Part view of experimental set-up for studying life-time of positron annihilation. The system is wholly indigenous. This is another instance of nuclear techniques being used for exploring material properties.**

# The
# Reactor Research Centre
# Kalpakkam

*Left* **: An experiment in progress in the sodium technology laboratory to study problems relating to deposition of sodium vapour on the rotating plug in the FBTR.** *Below* **: Experimental set-up for studying angular correlation of positron annihilation radiation.**





# BARC's Role in Protecting Radiation Workers

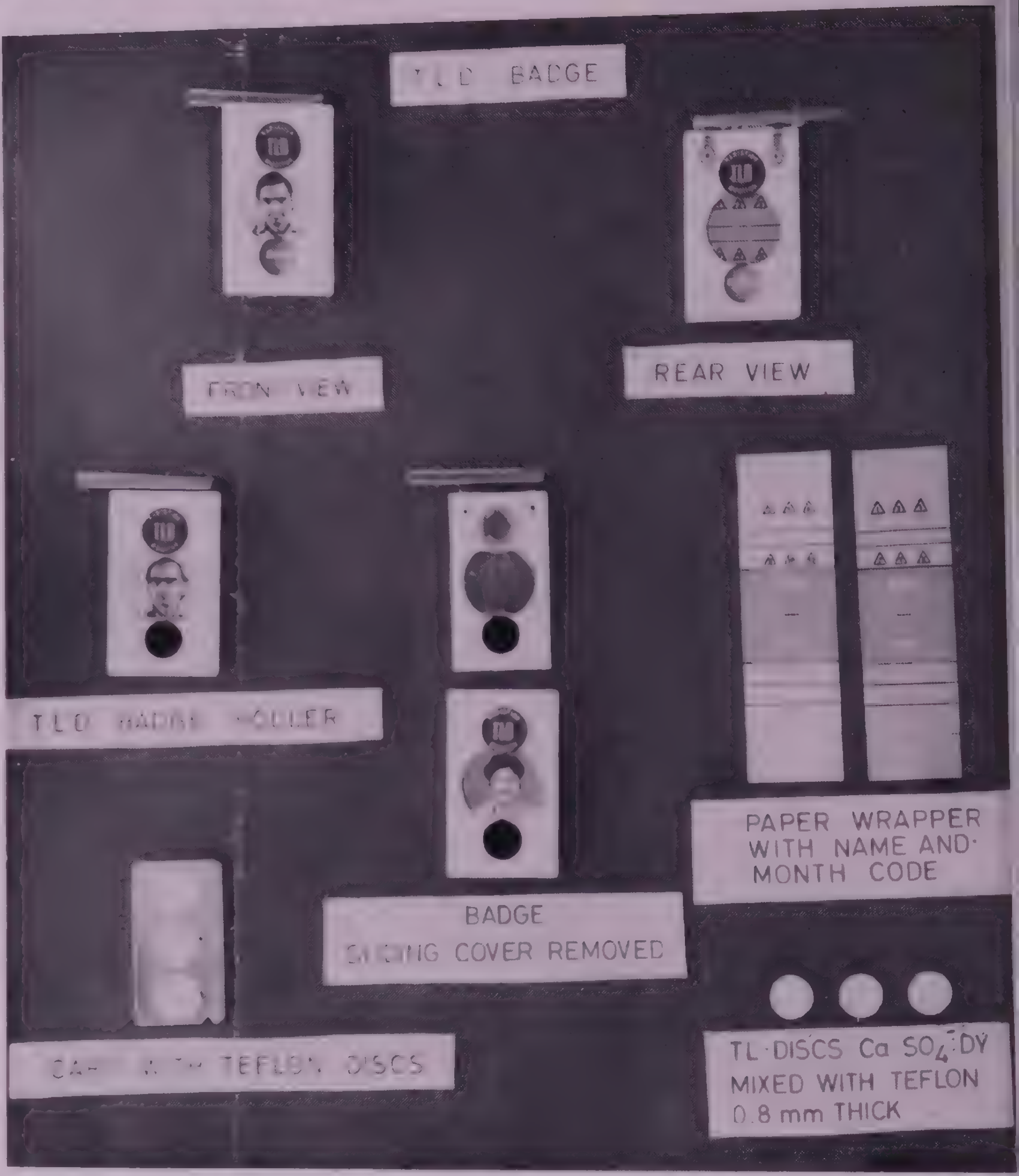
ANY discussion of the benefits of atomic energy invariably leads to a consideration of the safety aspects of its uses, and the efforts involved in protecting the individual and the environment from its potential hazards. Besides being used for power generation, atomic energy is finding increasing applications in many other areas in the country with the number of people involved in its application rising steadily. During 1976-77 there were 42,000 radiation workers and 3,500 institutions in India using radiation sources, as against 12,000 radiation workers and 1,000 institutions in 1967-68.

This growth in the number of people working with radiation sources bestows on the Department of Atomic Energy a special responsibility for their protection. Towards this end the Department keeps a close watch on all aspects of the use of atomic energy and monitors exposures, if any, of the workers to radiation. This responsibility is entrusted to the Division of Radiological Protection (DRP) of the Bhabha Atomic Research Centre (BARC).

The individual can be exposed to radiation directly or indirectly through the environment and the ecological system. The Division has a countrywide radiation hazard evaluation and control programme under which it monitors workers and establishments, and the environment in and around the area. The air pollution and associated ecological problems are growing, particularly in the urban areas, and the Division has undertaken several new studies in the field. The National Radiation and Environment Protection Programme of the DRP is implemented through separate groups constituted on the basis of more or less independent activity.

## Advisory Services

An effective radiation protection programme has to go hand in hand with a programme to encourage hospital physics and other associated problems in the country. The DRP therefore advises institutions on the proper layout of radiation installations to ensure built-in safety, and provides training on the use of radiation sources, besides supplying instruments and devices for radiation safety and radiation applications.


TLD BADGE
FRONT VIEW
REAR VIEW
TLD BADGE HOLDER
PAPER WRAPPER WITH NAME AND MONTH CODE
BADGE SLIDING COVER REMOVED
CARD WITH TEFLON DISCS
TL DISCS Ca SO$_4$:DY MIXED WITH TEFLON 0.8 mm THICK

**Personnel monitoring badges developed by the Division of Radiological Protection of BARC. (Please see adjacent box)**

A Safety Standards Group prescribes safety standards for transport etc, certification of industrial and medical radiation facilities, processing of applications for the import and export of radioactive materials, and conduct of countrywide advisory service covering some 1,200 installations. The group's functions are similar to those of the National Radiation Protection Board of the UK, the Atomic Energy Control Board and the Department of National Health and Welfare of Canada, the Atomic Safety and Licensing Agency and the Director of Regulations, NRC, of the USA.

## Medical Physics

Advise on radiation therapy is provided by the Medical Physics Group of the Division on problems related to the physics of treatment planning, and use of techniques and appliances for protection of patients and staff. The group also designs, fabricates and supplies applicators and other devices. It has so far supplied nearly 300 devices to about 40 medical centres in the country. These devices, incidentally, are not being supplied or manufactured by any other agency in India. The group has also developed sophisticated

## Film Badge Monitoring

Monitoring of radiation personnel in the country is a major activity undertaken by the Film Badge Dosimetry Group of the Division through a countrywide film badge service. The film badge is essentially a single film (Size 4.5 cm. × 3 cm.) worn outside in a holder by workers handling radioisotopes, or working in an establishment where radioisotopes and other radiation sources are used. The film records the exposure, if any, of the worker to radiation. The badge is analysed at regular intervals to ensure that exposure of the worker is within the permissible limits set by the International Commission on Radiological Protection (ICRP). Nearly 200 new institutions join the Division's personnel monitoring service every year, and a total of 2,50,000 film badges are analysed each year.

The Division has now developed a new type personnel monitoring badge—the thermoluminescence dosimeter badge—for monitoring radiation workers and has introduced it for field use in the Tarapur Atomic Power Station. These badges will eventually replace most of the film badges presently being used in institutions in the country. Thermoluminescence badge readers have also been developed and fabricated for quick, on-the-spot evaluation of personnel doses. To maintain centralised records, individual dose records and other data connected with the countrywide personnel monitoring services have been computerised.

computer techniques for providing isodose charts for treatment planning which is to be utilised all over the world through a projected publication of the International Atomic Energy Agency (IAEA).

### Assessing Genetic Effects

For the long term assessment of genetic effects, it is essential to know the genetically significant doses received by the population in a country from the practice of radiology. Gonad* dose measurements have been carried out so far on 15,000 patients from various regions of the country, and the age and sex distributions have been calculated for every 125,000 patients. Extension data on gonad dose is being accumulated on a countrywide scale.

### Studies on Ionising Radiations

Some basic studies on the effects of ionising radiations on the simple biological system, with the ultimate objective of understanding their effects at molecular and cellular level are also being carried out in the Division. Extensive studies have been completed using yeast cells. Sinergistic effects of simultaneous exposure to high and low LET** radiations have provided some very interesting results : it has been shown that low LET radiation is more effective when administered along with high LET radiation.

### Instrument development

To meet requests from institutions all over the country for special protection instruments needed in hospitals and industrial and research establishments, the Instrumentation Group of the DRP designs and develops protection instruments and other special

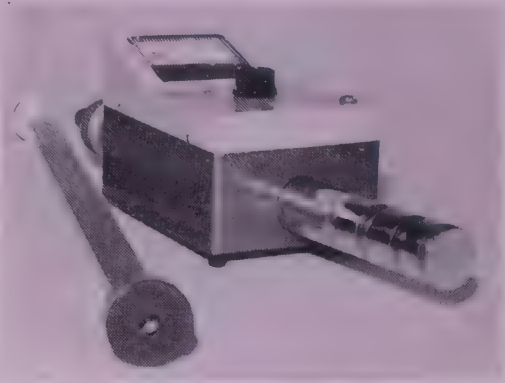
(*Continued on page 2*)

## Courses on Safety

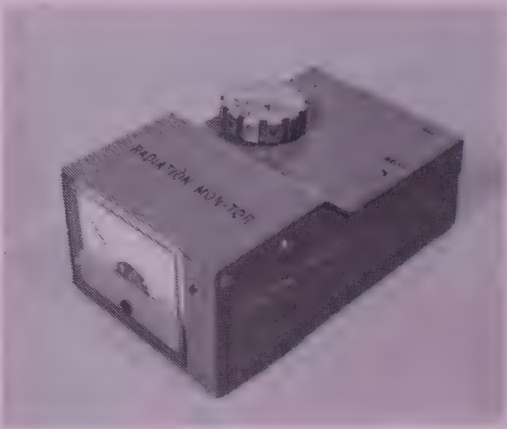
The Division conducts two courses every year on "Safety Aspects in the Medical Uses of Radiation" and two courses on "Safety Aspects in the Industrial Uses of Radiation" in addition to a one year course in "Hospital Physics and Radiological Physics" which is conducted in collaboration with the World Health Organisation and the University of Bombay. The successful candidates receive a diploma from Bombay University. So far 67 short-term courses have been conducted and around 1,080 candidates have been trained. 15 long-term courses have been conducted with a total of 225 trainees. The successful trainees include 17 scientists from abroad.

## Some Monitoring Instruments from BARC

**Thermoluminiscence dosimeter reader system**



**Wide range survey meter**



**Radiation monitor**

**Secondary standard dosimeter**

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**Gonad:* A genetic term for male and female sex glands.

***LET:* Linear Energy Transfer.

# IRE Records Consistently High Performance

*(Continued from page 1)*

plants are managed by the Minerals Division which is, in a sense, the hub of the Company's entire mineral sands operations. The Division is engaged in the separation of beach sands into mineral constituents like ilmenite, rutile, zircon, garnet, sillimanite and monazite. While monazite is sent to the Rare Earths Division at Alwaye for further processing, the other items produced at Manavalakurichi and Chavara are sold in the domestic and foreign markets. The sales turnover of this Division, which was a mere Rs. 27 lakhs in 1965-66 went upto Rs. 4.35 crores in 1976-77, half of which came from exports. The Division not only produces the basic minerals but also value-added products such as zircon flour, zircon opacifier, zirconium oxide, zirconium oxychloride, zirconium hydroxide, etc. The products of the Division are exported to the USA, Japan, F.R.G., Spain, Italy and the UK. New markets have recently been found in Taiwan, Iran and Egypt.

### *Thorium Plant*

The Thorium Plant at Trombay started production in 1955. The crude thorium hydroxide concentrate produced at the Rare Earths Plant at Alwaye is the feed material for this plant and the end products are thorium nitrate, thorium oxide, a few other compounds of thorium, small quantities of uranium, and rare earths fluoride. While these products, particularly thorium nitrate, are of commercial value to the gas mantle industry, refractories, polishing compounds units and in the manufacture of heat-resistant alloys, the real importance of thorium lies in its potential as a nuclear fuel in the coming breeder reactors of the country's nuclear power programme.

With the present annual output of thorium nitrate and some other products of thorium, the Company not only meets the entire internal industrial demands but also those of the USA, UK, Iran, UAR, Japan, Turkey, Sri Lanka, Bangladesh, Pakistan, West Germany and Spain. The total value of exports so far is of the order of Rs. 2.5 to Rs. 2.75 crores.

### *The Orissa Project*

Investigations carried out by the Atomic Minerals Division of the Department of Atomic Energy showed that a long strip of 18 km on the sea coast near Chatrapur in the Ganjam district of Orissa State contained heavy minerals of the same category as those found at Manavalakurichi and Chavara. Though the deposits in this region are larger, their heavy mineral content is lower. IRE has taken up the processing and development of the Orissa sands in a big way.

### *Sales*

In the early stages, the Company had to face considerable problems in its commercial operations. There was a time in the late fifties when the rare earths chloride had to be dumped in the sea owing to lack of demand. The Company persevered in its marketing operations, explored overseas markets and established a foothold in the USA and Japan despite stiff competition from established large scale competitors, adverse propaganda and several other depressing factors. Similarly, just before the Company took over the beach sands separation plant in 1965, the beach sands minerals market, in which India had a predominant share for a long time, was almost completely lost to big industrial competitors from other countries, especially Australia. The Company revived this industry and recaptured and expanded the market.

In recent years, in a depressing pigment market, the Company has been able to fight fierce competition from ilmenite exporters in other parts of the world, especially Northwest Australia, and has successfully penetrated into new markets in Taiwan, Iran, Egypt, FRG, etc.

The product line the Company deals in is of a nature where marketing data is generally kept a closely guarded secret by manufacturers all over the world. It is in this context of international competition and fluctuating market trends that the recent overall performance of the Company has to be viewed. The sales turnover, export earnings, gross profits, net profits — all reached an all-time high during the year.

The Company gained an unique position among the public sector undertakings with regard to profitability during 1976-77 by earning gross profits of 40 per cent on sales and 47.8 per cent on capital employed. The net profits earned was 21.8 per cent on net worth and 19.3 per cent on capital employed. During 1976-77 net worth per equity share of Rs. 1,000 increased to Rs. 3,505 as against Rs. 2,919 in the preceding year. Operating in a competitive export market the sales turnover increased to Rs. 9.38 crores in 1976-77 as against Rs. 6.02 crores in the preceding year. Even then the Company was able to maintain the gross profit to sales ratio of 40 per cent.

For its consistently high export performance IRE has so far-received seven awards from all India professional bodies such as the Indian Chemical Manufacturers Association, the Basic Chemicals, Pharmaceuticals and Cosmetics Export Promotion Council, Bombay, and Certificates of Merit from the Ministry of Commerce.

A recent study published by the Reserve Bank of India on the Corporate Sector for the year 1975-76 shows the average rate of gross profit on sales for the year in large companies as 10.4 per cent. According to the Annual Report for the same year published by the Bureau of Public Enterprises in regard to public sector companies, the average rate of gross profit on capital employed is 7.6 per cent compared to 29.3 per cent earned by IRE.

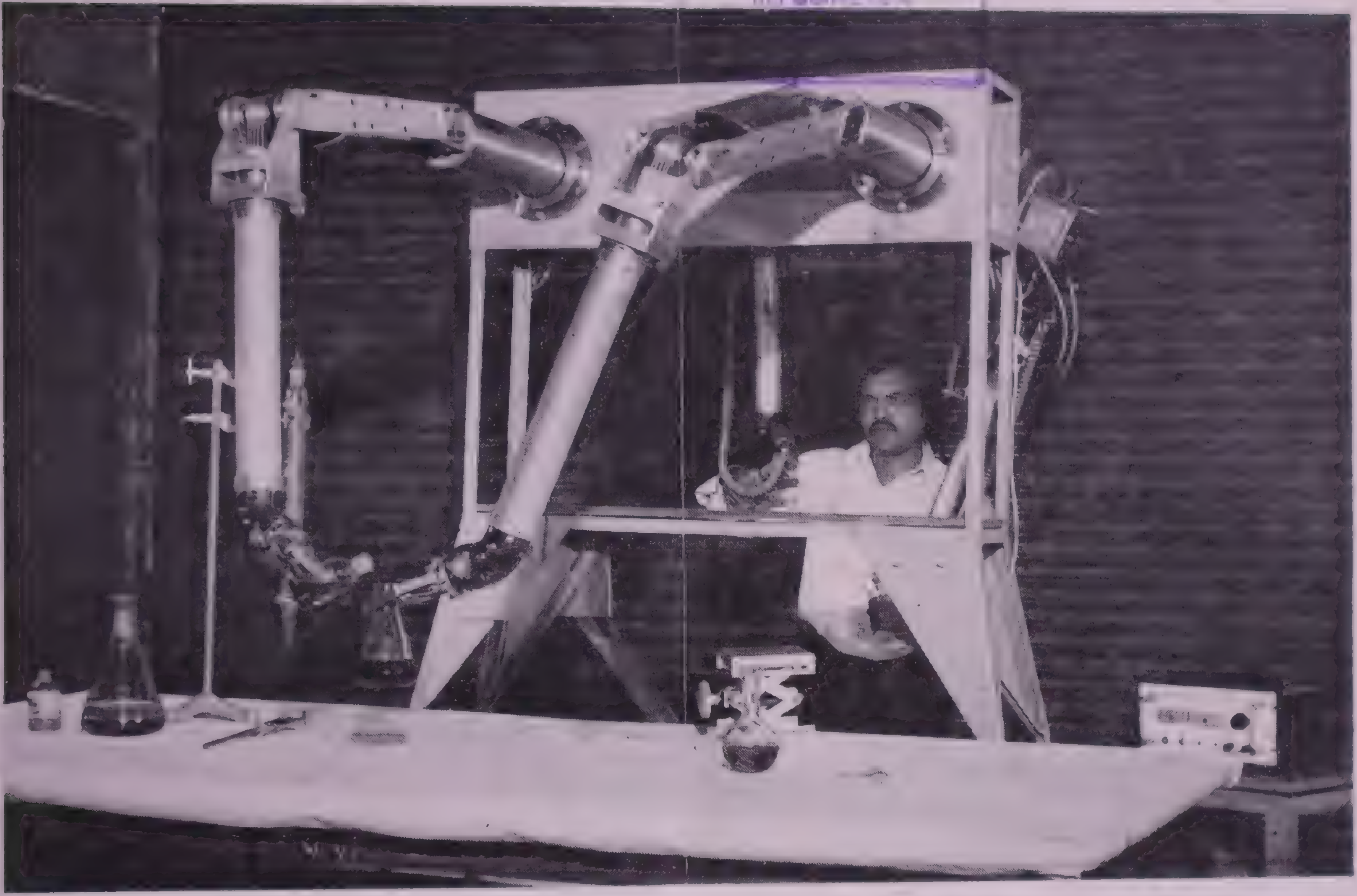
The reserves and surplus built up by the Company amounted to 154 per cent of the equity in 1976-77 as against 118 per cent in 1975-76. Nearly two-thirds of its income is out of exports. ●

Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India
Chhatrapati Shivaji Maharaj Marg, Bombay 400 039, and printed by him at G. Claridge & Co. Ltd., Bombay 400 001.

**Registered No. R. N. 9002/62**

NUCLEAR INDIA

VOL. 16 No. 7 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY MARCH 1978



# *Manipulators for "Hot Cell" Operations*

THIS articulated manipulator or "mechanical arm", designed and manufactured at the Central Workshops of the BARC, is a master-slave system used in lead-shielded 'Hot Cells' for conducting dexterous remote-controlled laboratory operations with radioactive materials. The manipulator is used in pairs, one for each hand, with each arm capable of shoulder, elbow and wrist motions, both at the master and slave ends. Seven independent motions can be imparted to the slave end from one master control, the movements being: up and down, clock-wise/counter-clockwise swing, forward and backward, wrist rotation, wrist elevation, azimuth rotation, and gripping action. These movements can be carried out either separately, or in any combination desired by the operator.

**Reach Capacity**

The system has a handling capacity of 4.5 kg in all these motions, with each unit capable of covering approx. 1 cu. m. of working space. By means of an electrical drive, any desired off-set of the slave arm with respect to the master control can be maintained, thus maximising the reach capacity of the manipulator.

The growth of the atomic energy programme has resulted in a rising demand for such manipulators. A recently conducted study shows that nearly Rs 2 crores worth of manipulators of both high activity and low activity hot cells would be needed in the country in the coming years. The BARC has developed some special models in its Central Workshops at Trombay and passed on the knowhow and technology to the industry for commercial exploitation. One model, CW-2-8, is already being made in large numbers by a private firm with

*(Continued on page [illegible])*

# Answers in Parliament

### Heavy Water Supply from Russia

Four heavy water plants (at Baroda, Tuticorin, Talcher and Kota) are in various stages of construction and commissioning. Sufficient quantities of heavy water from these plants will be available only in the next few years. Heavy water from the USSR has been obtained for meeting the immediate requirements of commissioning of Unit-2 of the Rajasthan Atomic Power Station, construction of which has been completed.

*(Lok Sabha, Feb. 22, 1978)*

### Requirement of Uranium for Nuclear Reactors

The Tarapur Atomic Power Station is the only station operated with enriched uranium as fuel. A quantity of approx. 17 to 21 tonnes of enriched uranium as uranium hexafluoride is required annually for optimal operation of this station.

Enriched uranium hexafluoride is obtained only from the United States of America in terms of the agreement for co-operation between India and the USA.

The shipment of enriched uranium is subject to US export regulations and consequently it is subjected to scrutiny in every case. Actual decision depends on the policy about nuclear energy which may be formulated by the US Government from time to time.

The Tarapur project is the only one depending on imported enriched uranium. The question of disruption of supplies to other projects does not arise. As far as the Tarapur Atomic Power Station is concerned, a dialogue is continuing with the US Govt. to assure continued supplies of enriched uranium in the future.

*(Lok Sabha, Feb. 22, 1978)*

### India's Stand on Nuclear Safeguards

The Government adhere to the view that all nuclear weapon tests should be banned.

*(Lok Sabha, March 1, 1978)*

### Nuclear Power Project at Kalpakkam

The Madras Atomic Power Project at Kalpakkam is behind schedule.

The main reasons for the delay are: (i) delayed deliveries of indigenously manufactured nuclear and conventional equipment, (ii) delay in the delivery of some equipment affected by the ban imposed by certain countries on the export of equipment/materials intended for nuclear power projects, and (iii) other causes like strikes, shortages of construction materials, etc.

Most of the equipments have now been delivered, including those affected by the embargo. The erection work has been speeded up wherever feasible. Precommissioning activities have also been taken up in parallel to reduce the time required after erection for commissioning and full power operation. The first unit of the Project is likely to attain criticality by December 1979 and the second unit in mid-1981. Full commissioning can be expected a few months thereafter.

*(Lok Sabha, March 1, 1978)*

### Setting Up of Atomic Power Plants in the Country

The setting up of new atomic power stations in future would depend upon the resources available, priority in terms of national policy and the most desirable mix of thermal, hydel and nuclear power stations to meet the overall demand for power over a specified time.

*(Rajya Sabha, March 2, 1978)*

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## *Mechanical Arms*

*(Continued from page 1)*

strict quality control and training from BARC. The technology of making such complex equipment was the exclusive preserve of a few advanced nations till recently. With the BARC's success in developing this equipment, the country's dependence on foreign sources has been reduced considerably. ●

## *Radioisotope Products, Services*

*(Continued from page 5)*

ces, such as radioisotope static charge (RISC) eliminators for use in explosives, textiles, films and rocket propellant manufacturing industries, Radioisotope Smoke Alarm (RISA) systems for forewarning of impending fire hazards in costly computer installations, defence establishments etc., and a variety of other equipment for the measurement and control of level, density, thickness and weight are available.

**12. Self-luminous Compounds**

Self-luminous paints and sealed light sources, produced using promethium 147, tritium and other radioisotopes are available for illuminating watches, aircraft instrument dials, safety signs aimpost markers and several other devices for commercial and defence applications.

**Radioisotope Smoke Alarm**

**Training & Advisory Services**

The Isotope Group offers training in various areas of handling and application of radioisotopes, preparation and quality control of radiopharmaceuticals, radioimmunossay, industrial isotope radiography and tracer applications. Assistance and advice are also offered to intending users for setting up laboratory facilities for radioisotope applications.

Enquiries regarding the products and services described in these pages may be addressed to:

The Marketing Executive
Isotope Group, Bhabha Atomic
Research Centre,
Trombay, Bombay-400 085.

# ECIL to Supply Troposcatter Antenna to the Soviet Union

The troposcatter communication antenna system made by ECIL.

THE Electronics Corporation of India Ltd. (ECIL), a Government of India enterprise under the Department of Atomic Energy, has secured two orders from the Soviet Union for the supply of troposcatter antennae and computer memory stacks.

Under the antennae export order, valued at Rs 59 lakhs, ECIL will supply two parabolic troposcatter antennae of 30 meter by 30 meter with associated feeds for setting up the Indo-USSR troposcatter communication link between Srinagar and Dushanbe. The antennae will be designed and fabricated by ECIL using wholly indigenous knowhow.

The Indo-USSR troposcatter link, one of the longest in the world with a path distance of 695 kilometres, will provide for direct communication between India and the USSR without a satellite. At present communication between the two countries is through satellite.

Under the second export order, ECIL will supply about 1,350 sophisticated memory stacks valued at Rs 3.65 crores to the USSR over a period of two years. The first consignment will be delivered to the USSR by the end of 1978. These memory stacks will be integrated into the Russian computers. ●

**STATEMENT OF OWNERSHIP**

Place of Publication: Dept. of Atomic Energy, CSM Marg, Bombay 400 039. Periodicity, Publisher's Name, Nationality and Address: Monthly, Jagannath Sharma, Indian, Dept. of Atomic Energy, CSM Marg, Bombay 400 039. Printer's Name, Nationality and Address: Jagannath Sharma, Indian, Dept. of Atomic Energy, CSM Marg, Bombay 400 039. Editor's Name, Nationality and Address: Jagannath Sharma, Indian, Dept. of Atomic Energy, CSM Marg, Bomyay 400 039. Name and Address of the Owner: Govt. of India, Dept. of Atomic Energy, CSM Marg, Bombay 400 039.

I, Jagannath Sharma, hereby declare that the particulars given above are true to the best of my knowledge and belief.

(Sd.) JAGANNATH SHARMA
March 1, 1978.

# Radioisotopes' Crucial Role at Kudremukh

RADIOISOTOPES came to play a vital role recently at the Kudremukh Iron Ore Project in Karnataka where they were used to investigate the nature of a geological fault.

As part of the Project, a dam is being constructed over the Lakya river for storing the tailings after the mined iron ore is concentrated for transport to Mangalore Port, on its way to Iran. The tailings are to be stored mainly to prevent pollution of the river system in the area. The project authorities wanted the geological fault found at the dam site to be checked to ensure that there was no hydraulic continuity from the reservoir side to the downstream toe. Hydraulic continuity could endanger the dam and the project site as a whole.

Early this year, scientists from the Bhabha Atomic Research Centre carried out a radioisotope tracer study in the area. They injected radioactive bromine-82 in the form of ammonium bromide into the fissure along with a large quantity of water, and continuously monitored the Lakya river and all visible seepage points for radioactivity. The radiotracer data revealed that the fissure was not connected to the river flow. It was also found that the fissure and two seepage points downstream were connected through an underground reservoir of a few thousand cubic metres, and seepage occurred whenever the reservoir water rose to a certain level. This investigation enabled the project authorities to take urgent remedial measures and prevent loss of project time. ●

**Nuclear India is published around the 20th of each month. To ensure prompt attention, all communication should be addressed to the Editor, NUCLEAR INDIA, Department of Atomic Energy, Chhatrapati Shivaji Maharaj Marg, Bombay 400 039.**

# Radioisotope Products and Services

RADIOISOTOPES and radiations are playing a major role in improving technological and industrial processes, in diagnosis and treatment of diseases, in improving agricultural productivity and as powerful scientific research tools.

Realising the important role radioisotopes can play in the Indian economy, a programme for the production of radioisotopes was started in India towards the end of 1957. Today comprehensive facilities for large scale production of radioisotopes have been installed and over 350 different radioisotope products covering a wide range of primary isotopes, radiochemicals, radiopharmaceuticals, radiation sources, as well as a variety of radioisotope equipment and instruments are routinely produced by the Isotope Group of the Bhabha Atomic Research Centre. Some of the products and services of this Group are described here:

### 1. Radio Pharmaceuticals

A variety of radiopharmaceutical preparations of iodine-131, P-32, Cr-51, Hg-203, Co-57, Co-58, Fe-59 in the form of injections, capsules and other oral preparations are available for use in important diagnostic and therapeutic procedures in nuclear medicine. Generators and kits for short-lived radioisotopes such as technetium-99m and indium 113m are also available for hospital pharmacy formulation.

### 2. Radioimmunoassay Kits

Radioimmunoassay (RIA) procedures are employed for evaluation of the concentration levels of vitally important biological ingredients such as hormones, vitamins, steroids, drugs etc. in health and disease. Some of the important RIA kits available include HPL (Human Placental Lactogen) kits which offer a valuable diagnostic procedure for evaluating complications in all stages of pregnancy, INSULIN kits for diagnosis of the prediabetic condition and management of therapy, and T3, T4 kits for precise evaluation of thyroid hormones for clear differentiation between hypo and hyper thyroids and normals.

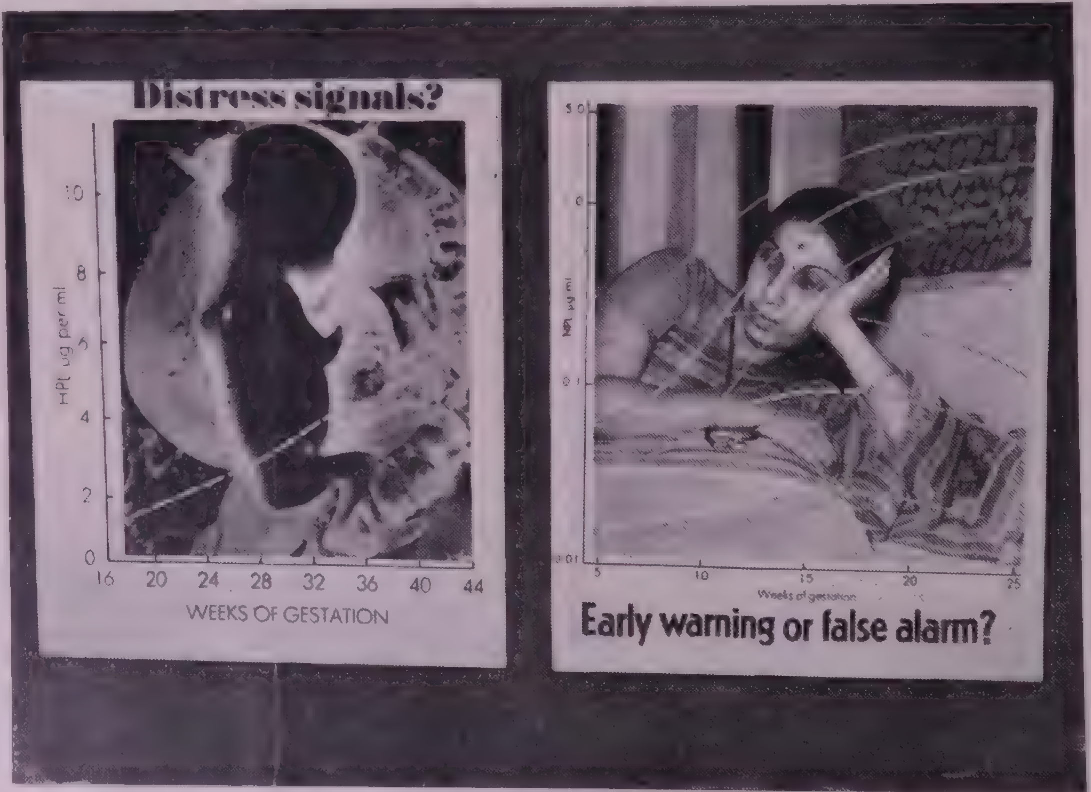
Indium 113m being milked out from a generator.

### 3. Radiation Sources for Therapy

Radiation sources of cobalt-60, gold 198, yttrium-90, cesium 137 etc. are available for intracavitory and interstitial treatment of cancer. Teletherapy sources made of kilocurie quantities of cobalt-60 are available for external radiation therapy in the treatment of cancer.

### 4. Radiation Sterilization Service

ISOMED, a radiation sterilization plant at Trombay offers gamma radiation service for sterilization of a number of medical products such as sutu-



Radioimmunoassay helps detect risk pregnancy at a very early stage.

# n BARC

res, surgical dressings, catheters, scalpels, gauze, plastic devices etc.

### 5. Primary Isotopes, Radiation Sources & Other Radiochemicals

A wide variety of reactor produced primary isotopes, such as iodine-131, phosphorous-32, cobalt-58 etc. in different chemical forms are available for research applications. In addition, radiation sources of alpha, beta and gamma emitters are supplied to suit customers requirements.

### 6. Labelled Fertilizers & Insecticides

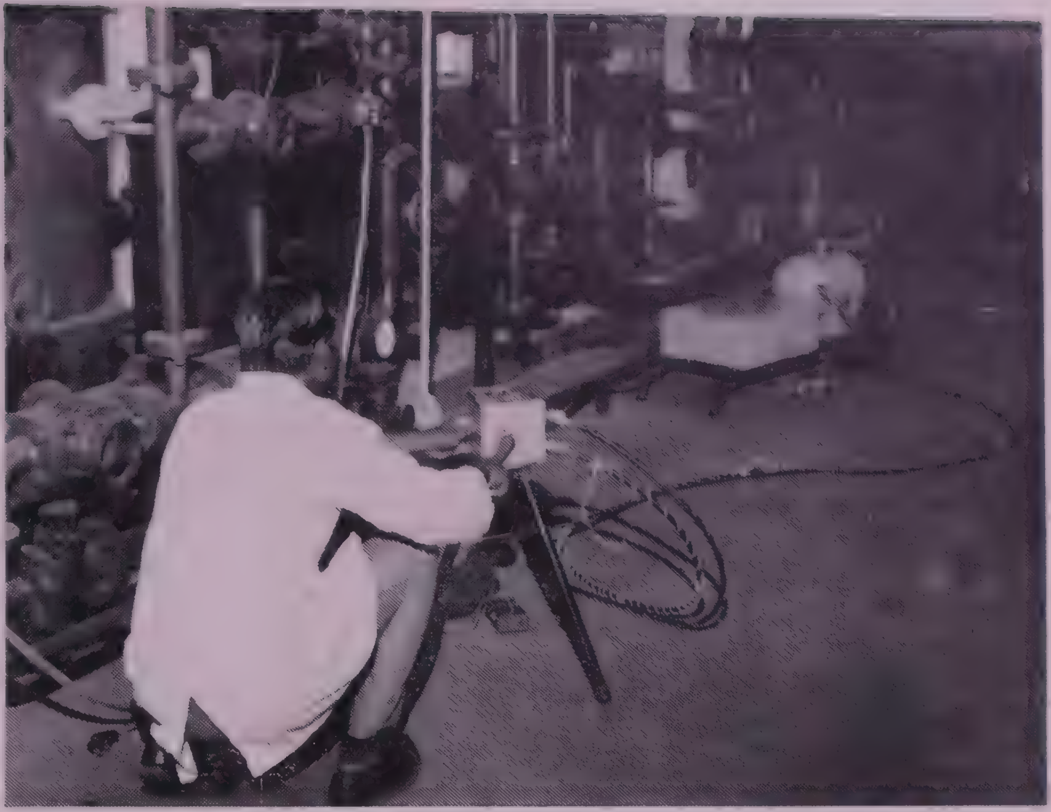
Labelled fertilizers and insecticides containing important radioisotopes such as phosphorus-32 and sulphur 35 are available for studying plant nutrition and for research work connected with the development of new fertilizers and improved methods for their application.

### 7. Carbon-14 and Tritium Labelled Compounds

A large variety of organic compounds, labelled with carbon 14 and tritium are available for advanced research in biochemistry, biological chemistry, as well as in agricultural and drug research. These include a wide variety of labelled amino acids, purines, pyrimidines, carbohydrates etc.

### 8. Laboratory & Industrial Irradiators

Self-contained gamma irradiators, holding upto several thousand curies of cobalt-60 and providing variable dose rates upto 1.0 megarad per hour are available for carrying out research work for the development of radiation induced chemical processes and for development of possible applications of radiation in biology and agriculture. Some of the irradiators readily available from the Isotope Group include Gamma Chambers with 1 litre and 4 litre irradiation volume, Gamma Shine for agricultural research, and Panoramic Batch Irradiator (PANBIT) for carrying out pilot scale radiation processes such as wood polymer composition, medical products sterilization and chemical syntheses.

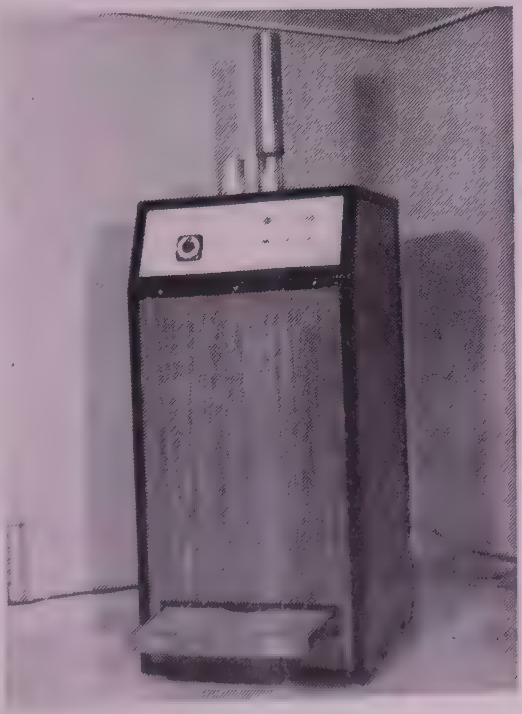


**Radiography in progress.**

### 9. Isotope Radiography Sources & Equipment

A complete range of radiography equipment, accessories and radiation sources, for non-destructive testing of flaws in welds and of voids in castings, is available. Radiography sources of cobalt-60, iridium 192 and thulium 170, which cover the entire range of steel and heavy alloy thickness upto 200 mm, are routinely supplied to several industries including heavy machinery, basic metals, petroleum, chemical and power industries.

**Gamma Chamber 900.**



### 10. Radioisotope Tracer Service

Radioisotope tracers provide a near ideal approach for the measurement and control of manufacturing processes, for the detection of leaks, blockages in buried pipelines, for wear testing of engines, tools, refractory lining in blast furnaces, for a clear understanding of industrial mixing and blending processes as well as for the better exploitation and exploration of oil wells.

In the field of hydrology, radioisotope tracers are extremely useful in solving most of the surface and subsurface tracing problems, including silt and sediment transportation in harbours, establishing seepage paths in dams and in several other underground water investigations like measurement of groundwater velocity, direction of flow, storage turnover etc.

The Isotope Group, BARC offers radioisotope tracer services for solving industrial as well as hydrological and civil engineering problems which are often of a special kind.

### 11. Industrial Radioisotope Equipment

Nucleonic gauges and other equipment incorporating radioactive sour-

(Continued on page 2)

# The MHD Programme and International Cooperation

by Vyacheslav Chernyshev

**Over the past two decades, research and development in magnetohydrodynamic (MHD) electrical power generation have been accompanied by a considerable upswing in international co-operation. The IAEA's MHD programme was launched in 1966 when it supported the initiative of OECD's Nuclear Energy Agency (NEA) to establish a joint group, which was called the Joint NEA/IAEA International Liaison Group on MHD Electrical Power Generation. This team of experts from 18 countries has been engaged in a regular exchange of scientific and technical information on MHD electrical power generation and has helped to find solutions to a variety of technological problems and to implement a number of design concepts.**

THE MHD generator is an energy converter working on the principle of interaction between an electrically conducting fluid and a magnetic field (Fig. 1). Interactions of this kind were investigated by Faraday at the beginning of the 19th century. In his first work on electromagnetic induction in fluids, Faraday sought to use the earth's magnetic field to measure the flow rate of the water in the Thames river. It was not until the early 1960's however, that the idea of a magnetohydrodynamic method for converting energy fully came into its own. Basically, an MHD generator is a device for directly converting thermal energy into electricity. There are three types of MHD cycle: open, closed and liquid-metal.

In the open cycle, the products of combustion of fossil fuel, seeded to improve ionisation, are released into the atmosphere after passage through the MHD system. The closed cycle presupposes continuous circulation of the working gas through a closed circuit. In this case, the heat source may be an ultra-high-temperature gas-cooled reactor, and a seeded inert gas can be used as the working fluid. The liquid-metal MHD system could use as a working fluid the liquid-metal from a fast-neutron reactor. The main difficulty with such systems is that of creating a flow of liquid with a high enough velocity.

From both the physical and engineering standpoints, the possibility of an MHD system operating in a closed or liquid-metal cycle has been firmly established. However, the potential use of these cycles in large-scale power stations has not yet been developed to the same extent as open-cycle systems.

An assessment of the development of power generation in the more advanced countries of the world shows that in the coming years (up to the year 2000) the bulk of their electricity will be furnished by conventional power stations burning organic fuel. In as much as expenditure on fuel at the present time amounts to 50-55 per cent of the total outlay on electricity generation (and will increase), one of the most important problems in power engineering is to improve the thermal efficiency of power stations, while reducing the thermal pollution of the environment.

Seen from this point of view, the magnetohydrodynamic method of electric power generation based on the open cycle is one of the most promising methods for directly converting heat energy into electricity, and will help to improve the economic viability of thermal power stations. It is expected that first-generation MHD power stations will have an efficiency of about 50 per cent, while for the second generation the figure will go up to 60 per cent. Even at the stage where first-generation MHD stations are introduced, the specific fuel consumption could be reduced by 20-30 per cent and the coolant water consumption could drop by a factor of 1.5 compared with normal thermal power stations.

### The U-25 MHD Facility

In the early 1970's the High Temperature Institute of the USSR Academy of Sciences constructed the first large MHD pilot facility, the U-25, which has successfully supplied electricity to the Moscow grid. The U-25 (Fig. 2) contains all the main components of future industrial power stations that will make use of an MHD generator.

The fuel selected for the U-25 facility is natural gas. Combustion takes place in oxygen-enriched air that is preheated to 1,200°C. To improve the conductivity of the plasma, use is made of a seed (alkaline metal) which is cycled to the combustor. The plasma flow, which has a temperature of over 2,500°C, generates an electric current in the MHD generator channel inside the field of the electromagnet. Inverters convert the direct current from the MHD generator into alternating current. The facility is controlled by a computer.

After passing through the MHD generator, the plasma gives up its heat in a steam generator and the steam is used in the secondary circuit steam power plant. Before the heat-depleted plasma is discharged into the atmosphere, the seed is extracted and recycled to the combustor.

In the combustor of the U-25 facility, the thermal load in the flow chamber reaches 70 x $10^6$ kcal/$m^3$.h which is approx. 300 times higher than is achieved in the best modern steam boilers. The characteristic feature of the MHD generator combus tor is that it operates under a very high potential—5 kW in the U-25. Work is still going on to select the most suitable type of MHD generator channel for the U-25 device so as to ensure continuous channel operation over a prolonged period and at rated power.

The principal design parameters for the U-25 have already been attained. The broad range of research performed with this facility has made it possible, even at the present stage, to begin construction of a pilot 500 MW MHD power station unit for industrial purposes. It should be pointed out that for large-scale production MHD power stations can operate under base-load, intermediate, or peak-load conditions.

### International Co-operation

There are many examples of international co-operation in the field of MHD electrical power generation. For instance, the co-operation agreement between the Nuclear Research Institute in Poland and the Saclay Nuclear Research Centre in France led to the construction of a high-temperature air heater (up to 1,200°C). A bilateral agreement on the construction of a coal gasification system was recently concluded between Poland and the USA.

There is a multilateral co-operation programme on MHD electrical power generation between the socialist countries within the framework of the Council for Mutual Economic Assistance (CMEA). India also, with the support of the USSR, has decided to set up a 15 MW thermal research facility to study the engineering problems involved in an open-cycle MHD system based on coal gasification. A good illustration of the development of international co-operation based on the MHD Liaison Group is the joint Soviet-American programme on the design and construction of industrial MHD power plants; this work has been progressing fruitfully since 1974. Because the U-25 facility contains all the principal elements of an industrial MHD power station, it offers the American experts an opportunity to test large MHD components under working conditions. For their part, the Soviet experts are interested in studying American-designed MHD-plant components, especially large super-conducting magnet systems and the operation of MHD generators that burn coal.

A major contribution to the joint USSR-USA co-operative programme was the installation in 1977 of a large American superconducting magnet system in a bypass loop of the U-25 facility. The superconducting dipolar magnet was built by the Argonne National Laboratory and flown to the USSR.

Over the next few years, there are plans for a joint Soviet-American study of a broad range of problems with the MHD generator using strong electric and magnetic fields (electric fields of upto 3 kV/m and magnetic induction upto 5 T). The outcome of this research will be of particular importance in the design and improvement of the main units of MHD generators to be used in industrial power stations.

The long-term activity of the International MHD Liaison Group supported by the IAEA and UNESCO, together with the various research and engineering programmes for international co-operation in the development of MHD, highlight the huge potential of this technology for the generation of electrical power in the future.

*(IAEA Bulletin Vol. 20, No. 1)*

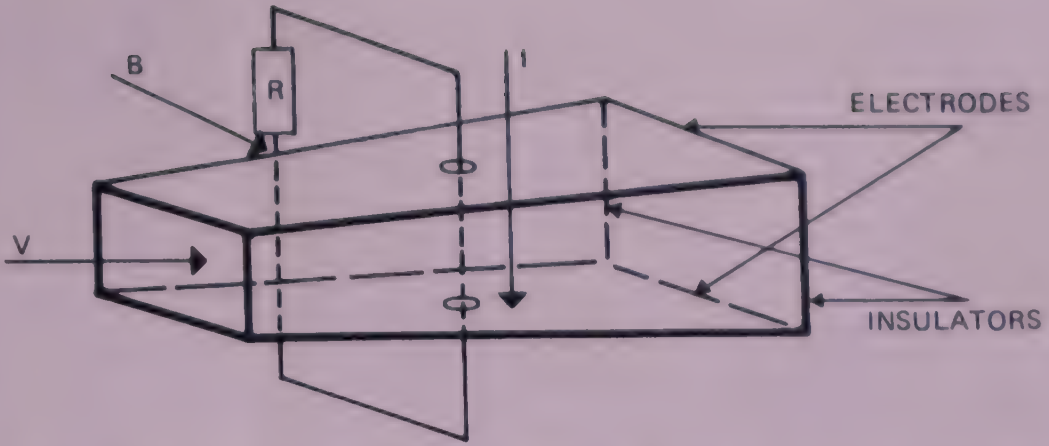
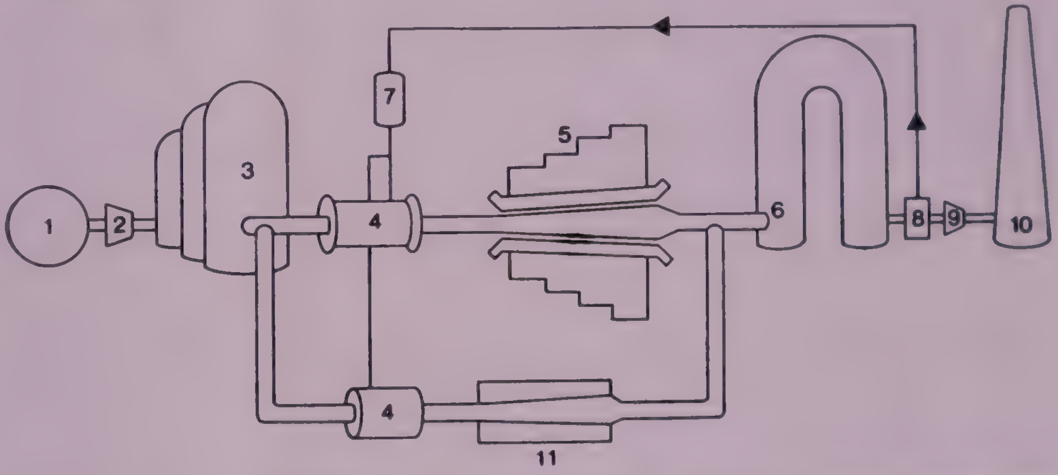


Figure 1. **Schematic of MHD generator channel. The flow of an electrically conducting fluid in a magnetic channel induces an electric field (intensity vector I), which is perpendicular to both the velocity vector V of the conducting fluid and the induced magnetic field vector B. During the flow of the fluid through the channel, a current is induced in the electric circuit with resistance load R. The channel power for a given magnetic field increases with the velocity and conductivity of the fluid. The fluid can be either ionized gases or liquid metal and is heated to a high temperature before it enters the MHD generator channel. The heat source can be a fossil fuel or a nuclear reactor.**

Figure 2. **Schematic of U-25 MHD power facility with by-pass loop for superconducting magnet system. (1) Natural gas source, (2) compressor, (3) air preheater, (4) combustor, (5) MHD-generator, (6) steam generator, (7) seeding system, (8) seed regenerator system, (9) stack exhaust blower, (10) discharge stack, (11) superconducting magnet system.**



**ECIL-made TDC-312 computer system which can be used for a variety of commercial applications like inventory control, production planning, payroll processing and financial and management information.**

# ECIL's TDC-312 Can Replace IBM 1401 H

THE Electronics Corporation of India Ltd. (ECIL) is well set to meet the needs of computer users who are planning to switch over from IBM 1401 H systems. The ECIL's TDC-312 commercial data processing computer system, equipped with magnetic tape drives, can replace the IBM 1401 H systems. The switchover can also be easily achieved since programs written for the IBM 1401 H systems can be executed on the TDC-312 systems without modifications. Besides, TDC-312 systems are much superior since they considerably minimise handling of the enormous volumes of punched cards inherent in essentially punched card processing systems such as the IBM 1401 H.

Apart from bringing down the cost of processing, the versatile TDC-312 system will also find use in a variety of commercial applications, including inventory control, production planning and control, financial and management information systems, besides routine data processing applications such as pay roll preparation etc. It can also be used as a powerful tool for scientific and engineering design applications.

### Over 100 Computers Installed

ECIL has already installed and commissioned nearly 20 commercial data processing systems. Some of the organisations where ECIL has installed the computers are: Dr. Beck & Co., Puné, the Indian Overseas Bank, Madras, the Gujarat State Fertilizer Company Ltd., Baroda, and the Cochin Shipyard. These units include systems installed under the rental plan as well as those on outright purchase. The Corporation has installed a system at its branch office at Bombay for demonstration purposes.

During the past seven years, ECIL has installed over 100 computers for use in real-time, scientific and commercial data processing areas. Today, one out of every four computers operating in the country is manufactured by ECIL.

An important feature of ECIL is its emphasis on total self-reliance in its production programme. Its effort in the field of computers is part of its overall objective of developing advanced technology wholly indigenously.

●

Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India,
Chhatrapati Shivaji Maharaj Marg, Bombay 400 039, and printed by him at G. Claridge & Co. Ltd., Bombay 400 001.

Registered No. R. N. 9002/62

NUCLEAR INDIA
VOL. 16 Nos. 8 & 9 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY APRIL-MAY 1978

## *Environmental Surveillance at Nuclear Sites*

# BARC's Efforts Towards Maintenance of Water Quality

> *"In water (rain), nutrients are produced.*
> *From nutrients, organisms are born"*
>
> BHAGWAT GITA

**The unique feature of the environmental surveillance programme at sites of nuclear installations in the country is the emphasis placed on maintenance of water quality, to protect citizens from radioelements and other pollutants.**

**Nuclear installations use large quantities of water for a variety of purposes — for clean-up operations, dilution of low level radioactive effluents, personnel decontamination, showers and toilets. When the waters are returned to the supply source after treatment, they still contain residual trace radioactivity detectable only with low level nuclear instruments after chemical separation. Shri P. R. KAMATH, Head, Environmental Studies Section of the Health Physics Division of BARC discusses here some of the studies pursued at the environmental survey laboratories established at nuclear power station sites in India.**

LIFE originates in water and grows on nutrients present in it—from the microbiotic to the adult stage. At each stage of growth along the ecological chain (algae—zooplankton—fish—man), pollutants get concentrated. The concentration of pollutants at each stage of the ecological chain is determined to identify the concentrating organism and the overall concentration in daily diet. On ingestion, the radioactive contaminants get deposited in human tissue and can be measured *in vivo* with a whole body monitor. The determination of whole body activity (Body Burden) in Man is thus the most important measurement as Man is at the top of the pollutant intake pyramid, and drinking water quality standards are developed for his protection. Whole Body monitoring of the fishermen living in the vicinity of the nuclear site (critical group) forms an important part of the radioactivity surveillance programme because, by their food habits and professional activities (*e.g.* fishing), they are the most exposed. Around 100-200 fishermen are examined every year on the Whole Body monitor at Tarapur.

The quality of water is maintained as long as radioactive discharges are well within specified limits, and its utilisation does not add to the body burden of pollutants. Water quality is best achieved by keeping the discharges very much lower than the reservoir's capacity to dilute, disperse and prevent build-up. Scientific investigations often reveal natural abatement processes in the water body which remove pollutants from circulation. Adsorption on silt and sediment, eutrophication and sinking of matted algae and dead organisms (debris) are natural abatement processes. Decontamination by this process is however not permanent since adsorbed radioelements may return to water by bacterial degradation and attack by benthic organisms.

**Environmental Survey Laboratories**

To monitor radioactive pollution in the environment, including Man, and for carrying out scientific investigations, Environmental Survey Laboratories (ESL) have been set up at all nuclear sites in the country. Measurements are made at first to establish a baseline of natural radioactivity before the installation is commissioned, and then to determine additions from plant operations. The laboratories are located far away from the operational sites to prevent their contamination and also to make them easily accessible to the public.

Investigations carried out at different sites comprise the following:

(i) Study of water movement and dilution, using radioactive isotopes and dye as tracers.
(ii) Identification of organisms which concentrate the pollutant (indicator) and finding the item of aquatic food in diet (critical food) which contains the highest concentration of pollutants.
(iii) Determination of body deposited activity in the most exposed population group (critical group).

(*Continued on page 2*)

(*Continued from page* 1)

### Environmental Survey Laboratories at Nuclear Sites

AN environmental survey laboratory was set up at the Tarapur Atomic Power Station site in 1964-65, five years before its commissioning. Similar laboratories were also set up, near the Rajasthan Atomic Power Station (in 1973), and the Madras Atomic Power Station, Kalpakkam (in 1975). A laboratory with an expanded scope of work for operational and environmental safety of scientists was constructed near the Jaduguda Mines of the Uranium Corporation of India Ltd. Similar facilities have also been set up at the Nuclear Fuel Complex, Hyderabad.

**Whole Body Monitoring in progress in the Rajasthan Environmental Survey Laboratory**

The organisation, programme and equipment of these laboratories are designed to match the special requirements of surveillance at each site.

### Varied Conditions

The sites at Tarapur and Kalpakkam are on the coast and subject to tidal circulation and silt transport. Creek and coastal fishing and sea salt production are major activities of the inhabitants. At Kalpakkam there is a natural radiation background from low concentration monazite in the beach sands. Radioactive pollutants like radium and thorium have been detected in the marine samples as a result of weathering. At the Hyderabad Nuclear Fuel Complex site there are no water sources close to the installation for dispersal of effluents. Well water is used for drinking and irrigation, ruling out disposals in pits. At Rajasthan, the Rana Pratap Sagar (RPS) supplies water for drinking in colonies, for condenser coolants and for services in the nuclear installation. The lake is located between the Gandhi Sagar Dam and the RPS Dam on the Chambal river. Maintenance of lake water quality is very important as the river supports several hydro-projects in its course and the waters are used downstream for drinking and agriculture.

Jaduguda is located in the Singhbhum mineral belt in Bihar. Mining of uranium causes release to the environment of vast amounts of mine water containing trace quantities of toxic chemicals like copper, nickel and radioactive decay products of uranium—particularly radium. The waste effluents from the Uranium Mill, and mine waters flow out of the site into public streams, and therefore concentration of the trace contaminants in water, fish and crops has to be watched.

### Hazards Still Present

If the water quality is assessed simply on the basis of concentration of pollutants in water and compared with safety limits for drinking water specified by Public Health Authorities, the water may pass the test, even after mixing with mill effluents and mine waters. The hazards from radioactive pollution in the water would however still be present because, simultaneously with dilution and dispersion, reconcentration of pollutants takes place in aquatic foods, thereby constituting a potential health hazard to the consumer.

**'Happa' for exposure of fish in thermal effluents**

**Temperature Meter for in situ measurements in the Rajasthan Lake**

During preoperational surveys at Tarapur and Kalpakkam, sea weed, algae, crabs, clams, shell fish, oysters and fish tissue were examined for trace elements like zinc, manganese and cobalt. Studies of this kind were carried out with the Atomic Absorption Spectrophotometer in the Environmental Survey Laboratory. The trace elements were found concentrated in these aquatic organisms to the extent of 100-1000 times of that in water. Oysters, crabs, clams etc. are good indicators of pollution in the aquatic medium.

From studies of trace element distribution in diet in the preoperational period, it is possible to predict in what tissue a particular radioactive pollutant would concentrate, and calculate the concentration factor. The actual concentration value for the radioactive pollutant is of course higher than that for trace elements. Oysters, crabs, clams and molluscs serve as good indicators of a number of elements such as Zn, Mn, Co and Fe, and their isotopic radionuclides $^{65}$Zn, $^{54}$Mn, $^{58-60}$Co, and $^{55-58}$Fe. Sea weeds are indicators of contamination by radiocobalt and radioiodine. Filamentous algae adsorb hydroxides of radiozirconium, radio-ruthenium and radiocesium produced by hydrolysis in water. Plutonium is also similarly detected in algae in ultra trace or weightless amounts. Radio-nickel, radiosilver and radio-tin have also been detected in the waters at Tarapur.

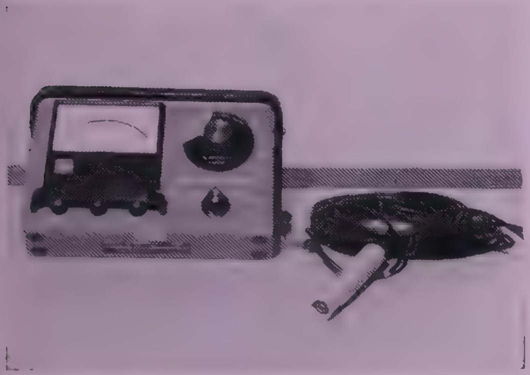
Measurement of trace radioactivity requires special types of nuclear instruments. Chemical processing of several kilograms of the sample material and separation by specific

# Oysters, Crabs, Sediment—Indicators of Radioactive, Chemical Pollutants

methods are required to isolate the trace contaminant for measurement.

Silt has high absorptive capacity for most radioactive and trace elements because of its reactive nature and due to organic material present in it Slit picks up radiocesium, which is widespread in the environment due to the fall-out from nuclear weapons tests. Suspended silt and sediment have been found to be versatile indicators of radioactive and chemical pollution. When contaminated silt gets deposited on beaches, there is radiation hazard to boatmen and the public.

The indicator system of monitoring for trace pollutants consists in examining the tissue that concentrates the pollutant to a maximum extent, instead of processing a number of large sized samples. The technique was found very useful for detecting radioiodine from French weapons tests deposited in grass. Iodine accumulates to the maximum in thyroid, and thyroids therefore serve as good indicator material. Thyroids of goats were thus obtained from the abattoirs and examined for the presence of radioiodine. Goat's thyroid was found to contain radioiodine from weapons test in a radiochemically pure form, and 14,000 times higher in concentration than in milk.



**Dissolved Oxygen Meter for in situ measurements in lake waters**

At the Rajasthan Atomic Power Project site, domestic waste effluents released on land after treatment flow into the lake supplying drinking water to the housing colonies. As a result of discharge, the water supplies are likely to get contaminated with released pollutants. The water quality may suffer further degradation from decay of submerged tree trunks. The Environmental Laboratory at the site has additional equipment to test piped supplies of drinking water, and discharges from sewage treatment plants. The water samples are examined for Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Salts (TDS), Dissolved Oxygen (DO), residual chlorine, nitrates, phosphates *E. Coli* etc. as described in Public Health specifications. Underground supplies of water from the Narora Atomic Power Project site are also being tested in the Rajasthan Laboratory for establishing a suitable source of water supply at the Narora site.

### Thermal Pollution

Unutilised heat from thermal power stations is discharged to the water body in condenser effluents, in a once-through circulation system. The condenser coolants rise by 8-10°C during power generation. Discharge of waste heat to the aquatic source is popularly termed as Thermal Pollution. Of the total heat generated in the thermal power station, only 30 per cent is converted into electrical power. The unutilised 70 per cent heat is discharged to the Rana Pratap Sagar directly. Condenser effluents are released in

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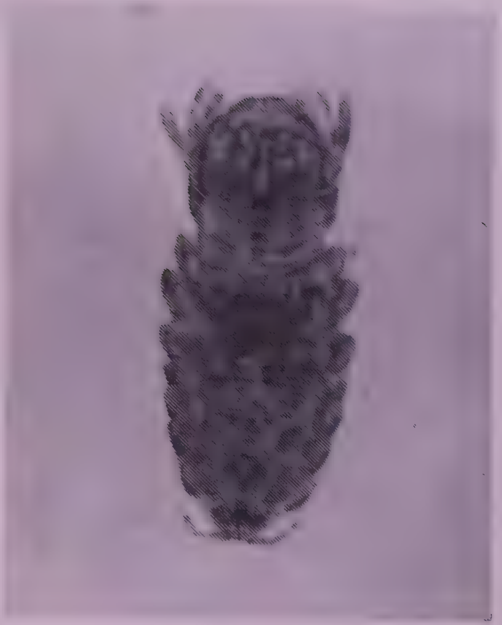
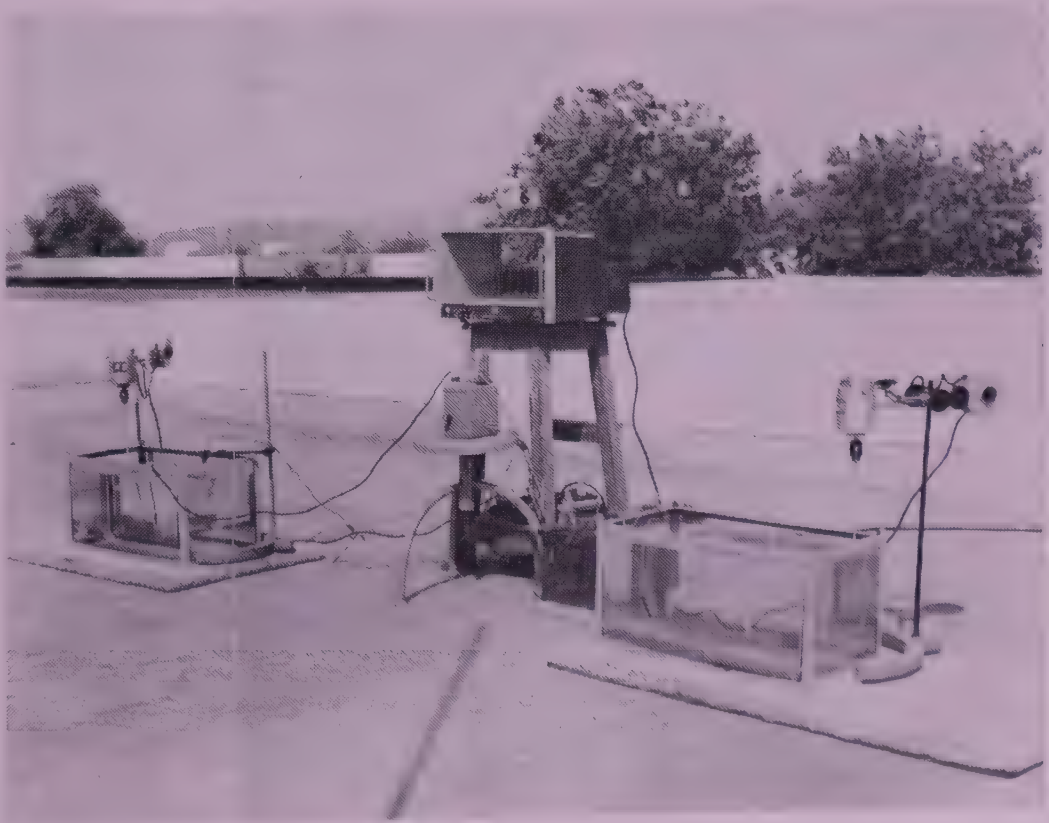


**Ectoparasite 'Alitropus Typus' found in large numbers on fish in the Happa in thermal plume**

**Thermally regulated experimental twin tanks for studies on parasite behaviour and synergesis. The tanks were developed at the Environmental Survey Laboratories at Tarapur and Rajasthan**



## *Atomic Energy 1977-78*

# Some Achievements, Some Se

Reactor safety vessel being taken to the reactor containment building for assembly and installation of the Fast Breeder Test Reactor at Kalpakkam, near Madras.

THE Power Reactor Fuel Reprocessing Plant at Tarapur, a wholly indigenously designed and built unit, is on an initial run reprocessing spent fuel, reports the Department of Atomic Energy in its Annual Report for 1977-78, released in April. Highlights of work in the Department during the year include commissioning of the VEC at Calcutta for the internal beam. A circulating beam of alpha particles accelerated to energies where it can produce radioactivity in copper was obtained at 6 a.m. on June 16, 1977. During subsequent runs, alpha particles were accelerated upto the full radius of 99 cm, which is the design radius for the extraction of the beam outside the cyclotron chamber.

The VEC was built by BARC entirely indigenously with the collaboration of a number of leading private and public sector industries. Work for obtaining an external beam is on.

At Trombay, construction work on a 100 MW thermal reactor (R-5 Project) is making good progress; the building superstructure upto the roof level is complete and major reactor components such as the reactor vessel, coolant channel assemblies, are under fabrication. This reactor will give an impetus to research and development activities in the fields of nuclear engineering, physics, chemistry, activation analysis and biology. It will also produce radioisotopes of specific activities higher than what is hitherto possible at Trombay.

A step in the direction of computer control of a nuclear reactor is the development at Trombay of a computer based control system for operating fuelling machines of the pressurised heavy water (PHW) type of reactors. Such reactors are at Rajasthan and under construction at Kalpakkam and Narora. This is the first sophisticated computerised control system wholly developed in the country.

### Radioisotopes and their Applications

The Bhabha Atomic Research Centre supplied over 40,000 consignments of radioactive products to users in India and abroad during the year.

The Centre installed a 50,000 curie cobalt-60 panoramic batch irradiator at a plywood unit at Baliapatam in Kerala in this period, and received an order for supplying and installing a similar unit with 75,000 curies of cobalt-60, on a turn-key basis, at the Pasar Jumar Research Centre in Indonesia.

Among the R & D work related to radioisotopes done during the year is the development of a scale-up process for wood polymer composites. This process will help the country tide over the scarcity of high-grade timber by upgrading the inferior na-

# acks

tive timbers with monomer impregnation and gamma irradiation. The Nuclear Research Laboratory at Srinagar has also been doing radiation polymerisation studies on cheap and fast growing local woods (willow and poplar) to assess the commercial feasibility of using them in the wood carving industry.

Among the important applications of radiations at Trombay is radiation sterilisation of medical products. ISOMED, the radiation sterilisation plant at Trombay sterilised 1,130 cu.m. of medical products during the year and also prepared 1,50,000 ready-to-use surgical kits for minor surgical operations.

The BARC has been engaged in developing new strains of groundnut, jute, rice and certain other crops. Groundnut strains (TG—Trombay Groundnut) were multiplied in Saurashtra, Maharashtra, Madhya Pradesh and Andhra Pradesh. About 2,000 tonnes of improved seeds were raised for further production. Yield studies showed that TG-17 was suitable for Gujarat and TG-3 for Madhya Pradesh.

In jute, five Trombay Jute (TJ) mutants were grown at different locations in Eastern India, along with check varieties, in yield trials under the All India Co-ordinated Programme on Jute and Allied Fibres. One of them (TJ-32) gave 26 per cent more fibre yield compared to the highest yielding check variety.

**Personnel Monitoring**

The Department's country-wide personnel monitoring service for evaluating radiation exposure covered around 45,000 workers from nearly 2,400 institutions. Country-wide radiological protection surveys, covering source loading operations of teletherapy units, were also conducted in 138 medical, 19 industrial and 6 research units.

**Reactor Research Centre**

The Fast Breeder Test Reactor under construction at Kalpakkam will shortly be moving into the phase when equipment can be installed. The civil works of the project are almost over and there is good progress in the manufacture of important reactor components. The RRC has also made noteworthy progress in R & D work relating to sodium technology, material science, metallurgy, reprocessing, and safety, all part of the fast breeder programme.

**Power**

The year witnessed fluctuations in the output of power from the Tarapur Atomic Power Station, and Unit-I of the Rajasthan Atomic Power Station. The record of output from Tarapur under the given circumstances has however been very good. During the first 11 months of the year the station generated 1,910 million kwh, registering a capacity factor of 57 per cent. It supplied 988 million kwh to Maharashtra, and 773 million kwh to Gujarat. This is 103 per cent of the generation target for this period as accepted by the Central Electricity Authority. Unit-I of the station achieved an uninterrupted run of 140 days at normal output from May 14 to October 1, 1977, which is among the longest for large units in the country. Its monthly capacity factor of 95.1 per cent during July 1977 was the highest since its commissioning in 1969.

Owing to changes in the nuclear policy of the U.S., fuel supplies are becoming more stringent, and future supplies are not assured, notwithstanding the contractual obligations of that country.

The Tarapur station's boiling water reactors are amongst the earliest of that type. As such, a number of design changes running to more than 200 have been incorporated in them by TAPS personnel.

At the Rajasthan Atomic Power Station, Unit-I generated 198 million kwh during the year. It was shut down for annual maintenance on July 2, 1977, but maintenance work could not proceed apace because of a strike which crippled all work between September 8, 1977 and January 7, 1978. The maintenance works are now on.

At the Madras Atomic Power Project, major nuclear and conventional equipment for Unit-I have been erected. For Unit-II, the steam generators, and turbine and condenser are being erected and the generator transformer has been installed. The calandria has been fabricated, and manufacture of the end shield is in an advanced stage.

At the Narora Atomic Power Project, most of the process design and flow sheets have been finalised. The main plant civil works are in full swing, and major nuclear and conventional equipment are under fabrication.

**MHD**

Another important R & D project on hand at the Department is concerned with Magnetohydrodynamics (MHD) Power Generation. Located at Tiruchirapalli, the Project is a joint venture of BARC and Bharat Heavy Electricals Ltd. The MHD technique relates to the direct conversion of thermal energy to electrical power. The technology is expected to improve the thermal efficiency of fossil-fired power plants from the present 30-40 per cent to 50 per cent, and even higher.

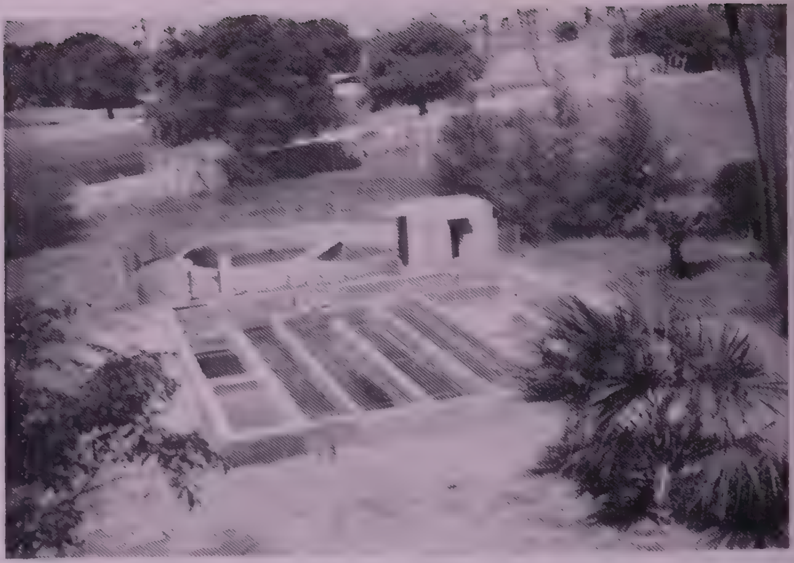
**Heavy Water**

The schedules of the heavy water projects have had to be readjusted. The Kota Heavy Water Project was affected by the strike at Rajasthan between September 1977 and January 1978, while the Baroda Heavy Water Plant was shut down due to an accident on December 3, 1977. The Tuticorin Heavy Water Plant has been tested and commissioning operations are on. At the Talcher Heavy Water Project, the civil works have been completed and the plant is expected to be ready for pre-commissioning tests by July 1978.

**Nuclear Fuel**

Self-sufficiency has been attained

*(Continued on page 10)*



**Top left: The Rajasthan Laboratory's motor boat 'Deepti' with meteorological outfit for lake water survey. Top right: Algal tank and fish pond at the Environmental Survey Laboratory at Kalpakkam. Centre left: Bio-gas production from algae grown in the Environmental Survey Laboratory at Kalpakkam. Bottom left: Madras Atomic Power Project reservoir surveyed for algal production.**

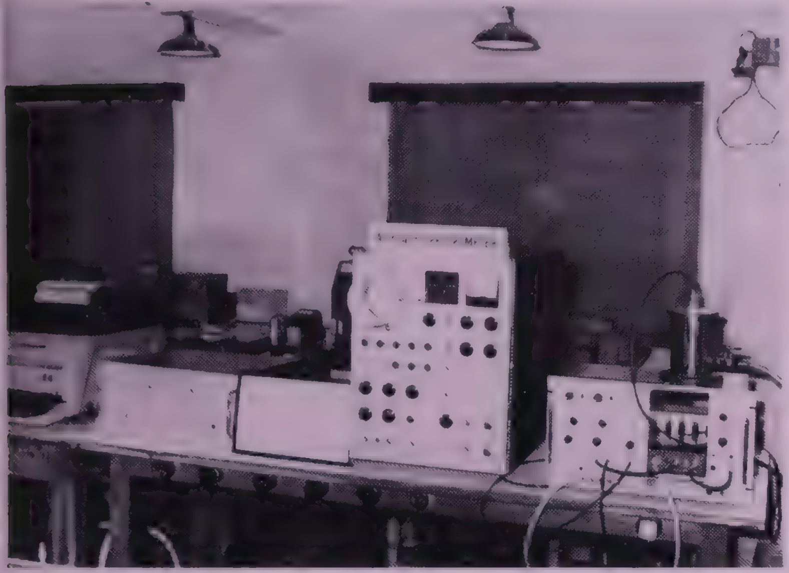
(*Continued from page 3*)

some stations through abatement systems like cooling towers and ponds. The immediate impact of unabated thermal discharge is a rise in the temperature of waters in the outfall region. The temperatures in the range of 37-40°C are close to the temperature of the human body and therefore there is a possibility of replication of human pathogens present, even though *E. Coli* die fast in this range.

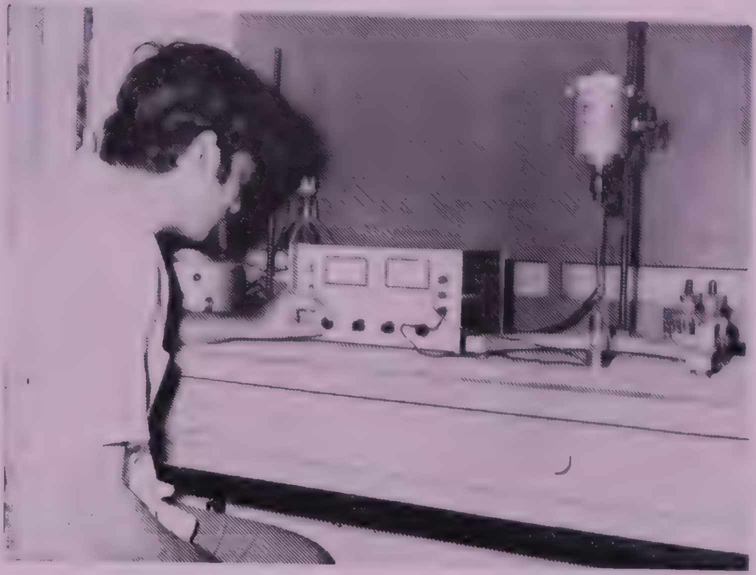
Other streams from the installation mix with the condenser effluent before discharge and help in some measure to reduce the temperature of effluents. The dissolved oxygen (DO) content in heated waters is slightly lower than in the coolant waters as a function of temperature. The DO gets further reduced if organic matter present in coolant water is oxidised at the expense of DO.

Surveillance for thermal pollution effects was carried out in the Rajasthan Laboratory: the Rana Pratap Sagar (RPS) is a stagnant water body (except for wind-influenced water movement at the lake surface). The rate of heat dissipation is slow. An *in situ* Temperature Meter was used in the lake for plotting the

# Gas Bubble Disease Due to Oxygen Supersaturation



**Spectrometer for alpha differentiation of Pu and other transuranics (ESL, Tarapur)**



**Electrode position of ultra trace plutonium for measurements (ESL, Tarapur)**

vertical profiles of temperature. A Dissolved Oxygen Meter was employed similarly. Lake surveillance was carried out using portable instruments on the ESL boat. Weatherometric equipments were also mounted on the boat to measure wind speeds and direction at lake surface, air temperature, humidity and pressure.

Thermal surveillance trips were made in the lake once every fortnight, except during the rainy months. The seasonal influence on thermal stratification was found to be quite strong. The temperature profiles showed the existence of a stable thermocline in the six months following winter. The thermocline separates the cool waters below the thermocline from the epilimnion water exposed to the sun. The temperature of the hypolimnion waters was found to be 15-20°C in the hot season. The design of the condenser circulating system is such that the intake waters to the condenser are drawn from waters close to lake bottom and the discharge is made to the lake surface. The intake waters are deficient in oxygen compared with the surface waters where, by photo-synthesis and mixing, dissolved oxygen is at saturation level. Two interesting observations were made during thermal pollution monitoring work:

(i) The temperature of condenser discharge was found to be lower than that of the surface waters in the lake in the hot months following winter.

(ii) The intake waters, which are deficient in DO, improved in dissolved oxygen content during cir-

(*Continued on page 8*)

**Solar ponds for evaporation of waste effluents**

**Environmental Survey Laboratory (Unit: Kalpakkam)**

# Environmental Studies Supported by Tro

(Continued from page 7)

culation in the condenser. The discharged effluents were richer in DO than intake waters.

Death of fish by supersaturation of gases in waters has been reported near the hydro stations when the DO content is very high. Oxygen supersaturation chokes gills with suffused gases, causing the fatal 'Gas Bubble disease'. The tropical waters are more likely to have oxygen supersaturation during the day-long hours of photosynthesis. The dissolved oxygen content required to reach saturation is also less at higher temperatures. The condition of fish under the State of oxygen supersaturation was studied in the laboratories at Rajasthan and Kalpakkam. Fingerlings were introduced in large experimental tanks containing water green with algal growth. Dissolved oxygen, and temperature were measured in the waters every two hours. Gas bubbles were seen to escape from waters accompanied by increased algal growth during noon hours. Fish were seen to die in two days of exposure; within a week all the fingerlings died, showing signs of asphyxiation. Such lethal effects have not been observed in the intermixing zone at the outfall.

### Blood Sucking Parasite

FOR determining the direct effect of thermal discharges on fish life, a cage (Happa) of nylon netting was prepared and kept half submerged in the thermal plume in the discharge canal. The net allowed free flow of heated effluents through the cage. About 50 fingerlings were kept in the cage, and fish feed was supplied through a trap door on top. A similar cage was kept upstream as control. On examination after three months (summer), the fingerlings in the discharge channel were found to have lost in body weight. On a closer examination, a large number of ectoparasites was found attached to gills, lips and other soft parts of the fish in the 'hot' cage. The parasite was identified as *Alitropus typus*, a blood sucking parasite, reported to be present in some landed fish from the Rajasthan lake. In contrast a very small number of parasites were found on the fingerlings in the control cage kept upstream. Parasite proliferation is a probable effect of thermal pollution and will be looked for carefully in fish found near the outfall. The parasite behaviour is under study in the Rajasthan Laboratory in twin aquaria tanks, the temperature of one being maintained 2-3°C above the other, which represents the lake water upstream.

**Self-energised continuous effluent sampler developed at ESL, Jaduguda**

The temperature of the tank is adjusted, with corresponding increase of 2-3°C in the twin tank, to represent conditions in the intermixing zone round the year near the outfall. The twin aquaria equipment is being used for study of synergistic effects of thermal pollution in the presence of chemical pollutants like chlorine, chromate, copper, mercury, arsenic etc. The changing concentration of the chemical pollutants in the tank is followed with Specific Ion Meter for *in situ* measurements. An extension to ESL, Rajasthan has been completed to accommodate the Aqua Lab. for such studies.

SOLAR ENERGY can be utilised for control of domestic pollution, by growing algae using the nutrients present in sewage effluents. Algal growth removes nutrients and contaminants in an oxidation pond. The tank for algal culture and pond for fish culture were built in the compound of the Environmental Laboratory, Kalpakkam, for rearing Scenedesmus. Pilot experiments were carried out in the laboratory to produce biogas from algae grown in the tank. Laboratory experiments showed that biogas produced with algae has higher burning power. A pilot plant is being designed for using a charge of 5-10 kg algae at a time. The reservoir at the Madras Atomic Power Station, containing about 30 million litres of water, is under survey for commercial production of algae.

Solar evaporation is proving increasingly useful for keeping down pollution in land-locked areas. At the Nuclear Fuel Complex at Hyderabad ponds have been built to expose effluents to the sun to recover the solids. No effluents are released to the environment in principle. Seepage is prevented through leak proof construction.

### Pollution at Mine Sites

The Jaduguda Mine site in Bihar presents a very challenging opportunity for study of environmental control of pollutants. Large volumes of water containing trace toxic elements—radium, manganese, copper and others, are released during mining operations.

The waste slurries from the uranium mill at Jaduguda are piled up as a heap on land, called the Tailings Pond. When solids settle down, liquids flow into the drains leading to the river. They contain salts of uranium, radium, manganese, nickel and others. The pollutants get concentrated in algae, paddy, vegetation and fish. The waters from the tailings pond and drains have been detected in well waters on the site. The total amount of toxins that are present in the

# y Research

effluents are determined from collection of day-long samples from the effluent streams with continuous samplers fabricated in the laboratory. A large laboratory has been set up in Jaduguda for collaborative investigations of the operational and environmental safety aspects.

### Research Projects

Field monitoring of pollutants and investigations on radiation background bring out special aspects of pollution in the environment calling for a change in priorities and programmes. The Kalpakkam beach was found dispersed with small amounts of monazite which, on weathering, released thorium and radium in ultra trace amounts into sea waters. An International Atomic Energy Agency Research Coordination Project for the study of radium distribution has been initiated in the Kalpakkam Laboratory in collaboration with the Jaduguda Laboratory.

A second IAEA Coordination Project entitled "Thermal Pollution at Nuclear Power Stations in India" has been initiated in the Rajasthan Laboratory. Essential instruments for *in situ* measurements of temperature, DO, pH, conductivity, were procured for project work through IAEA. A third IAEA coordination project has been awarded to the Tarapur Laboratory for advancing the programme of the laboratory for measurement of transuranic elements—Pu, Am, Cm—in the marine environment. The 14-year old Tarapur Laboratory has been extended, with an attached wing for alpha measurements. Estimation of transuranic elements requires special electro-deposition procedures and an alpha spectrometer for analysis.

During the past 20 years, environmental surveys have been carried out at every site of atomic energy operation in the country. The first ever tracer study carried out by the Environmental Survey Group used a radioisotope of sodium to find dilution availability and water turnover in the Trombay Bay in 1959. Water movement studies were carried out similarly at Tarapur, Kalpakkam and Rajasthan in the water body using the dye Rhodamine B as the tracer. The colour patch enables a visual assessment of moving waters, and dilution at any time in the waters can be determined from measuring the dye content in the water sample with a colorimeter. Environmental investigations have been carried out and data collected on indicator organisms, recipient water characteristics, critical group of population, and food. Whole body monitoring of the critical group of population is carried out after the reactors are commissioned to determine body deposited activity. Analytical techniques and data evaluation have been used to bring out the special features of each site and to predict distribution of pollutants in the environment on discharge.

Environmental surveillance studies are strongly supported by research carried out at Trombay. The laboratories analyse samples for cross checking results with the international reference centre of the Who at Paris. Studies are now afoot in the Environmental Laboratory at Trombay for processing waste solutions containing pollutants which have recently caused public concern, namely, Mercury, Beryllium and Cadmium. ●

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# Answers in Parliament

### India's Cooperation for Development of Nuclear Energy

Algeria, Columbia, Guyana, Madagascar, Peru, Mexico, Venezuela, Indonesia and Vietnam have sought India's co-operation for developing nuclear energy for peaceful purposes

India has entered into bilateral agreements for co-operation in the peaceful uses of atomic energy with Afghanistan, Argentina, Belgium, Bangladesh, Canada, Czechoslovakia, Arab Republic of Egypt, France, FRG, GDR, Hungary, Iran, Iraq, Italy, Poland, Romania, USA and USSR.

(*Lok Sabha, April* 5, 1978)

### Uranium and Its Mine Operations in Bihar

Uranium ore of low but reasonable grade is available at Jaduguda and is being mined systematically by Uranium Corporation of India Ltd, a public sector undertaking of the Department of Atomic Energy. At Narwapahar, the grade of uranium is very low and not exploitable. At Rakha, the ore is being processed by Hindustan Copper Ltd, a public sector undertaking of the Ministry of Steel and Mines, mainly to recover copper, besides producing tailings containing low grade uranium.

The mining operations at Jaduguda are being carried out by the UCIL, while the Hindustan Copper Ltd is looking after the operations at the Rakha mines. At Narwapahar, developmental mining work by the Atomic Minerals Division of the Department of Atomic Energy was on before 1974, but regular mining and production had never commenced as the operation was considered uneconomical due to low grade uranium content in the ore, and absence of copper; besides, the mines could not be worked for by-product recovery.

(*Lok Sabha, April* 5, 1978)

### Monazite and Ilmenite in Orissa

Indian Rare Earths Ltd, a public sector undertaking under the administrative control of the Department of Atomic Energy, is setting up an integrated industrial complex for the commercial exploitation of deposits of rare earth minerals monazite and ilmenite.

(*Lok Sabha, April* 5, 1978)

# Tantalum Production Process Perfected at NFC

(Continued from page 5)

in the manufacture of fuel required for PHW type of reactors.

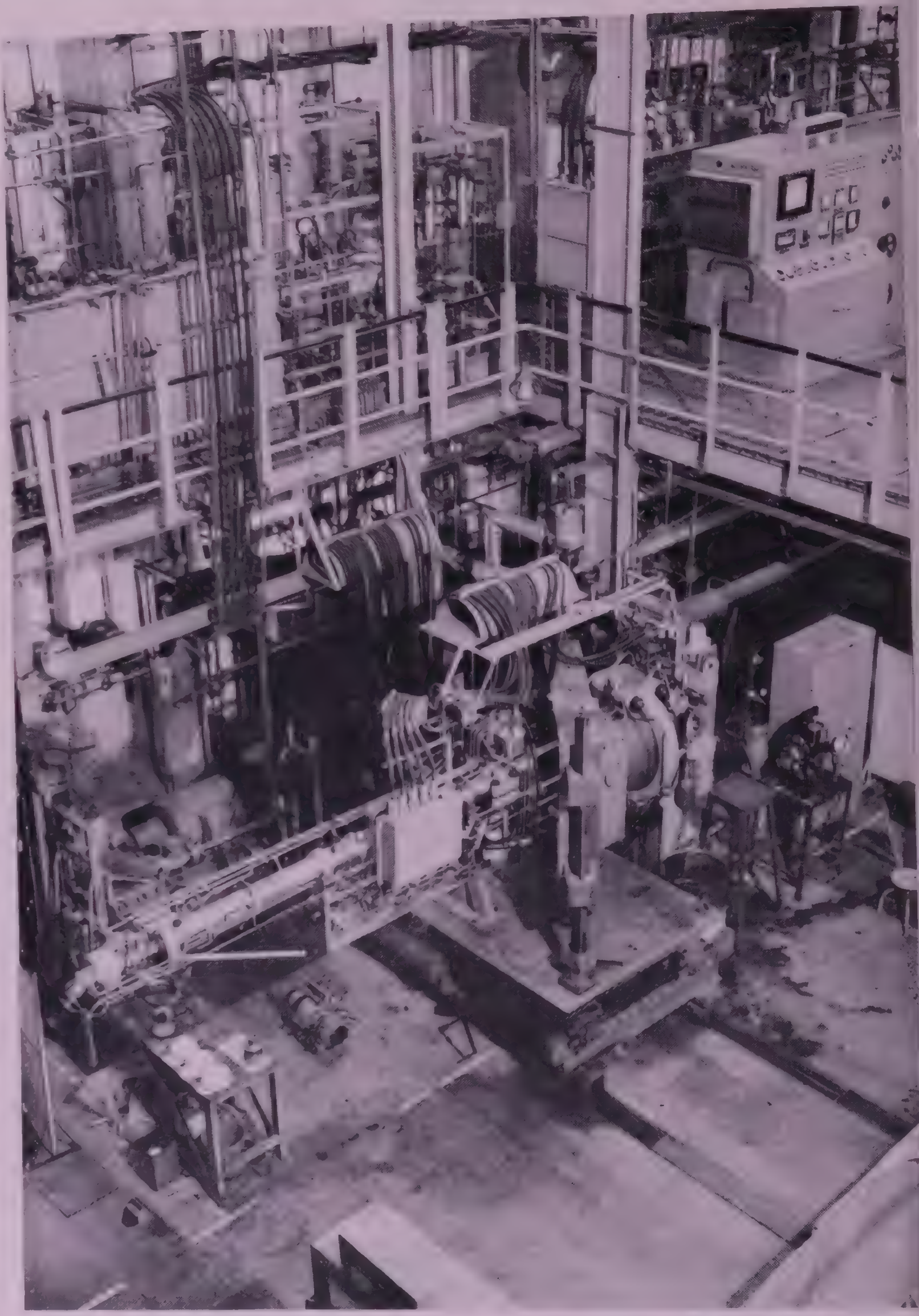
The Nuclear Fuel Complex at Hyderabad supplied coolant tubes for the Madras Atomic Power Project, Unit-I, and the initial core requirement (4,000 fuel assemblies) for Unit-II of the Rajasthan Atomic Power Project during 1976-77 and 1977-78. Supply of coolant tubes has resulted in a saving of foreign exchange of Rs 1.8 crores.

The Special Materials Plant of the Complex perfected the tantalum powder production process, the technology for selenium doping and production of sodium iodide. This development will help meet almost the entire requirements of the country in these three items.

Three more plants *viz.* 2,000 tonnes Stainless Steel Seamless Tube Plant, 21,000 tonnes Ball Bearing Tube Plant, and FBTR component assembly shop are also being set up in the Complex.

**Atomic Minerals**

Intensified efforts by the Atomic Minerals Division during the year has brought to light promising uranium occurrences at Bhandaritola in Rajnandgaon district (Madhya Pradesh), Ingedinala in Theri district (Uttar Pradesh) and Gomaghat-Alukwadi in Khasi Hills district (Meghalaya) where sub-surface exploration by drilling has commenced. The Division also produced around 11.41 tonnes of columbite-tantalite during the year. Exploratory drilling during the year by the Division aggregated around 18,038 metres.



**Fuelling machine for the Rajasthan Atomic Power Station's Unit II, fabricated by BARC, being tested under simulated operating conditions**

**Public Sector Undertakings**

*Indian Rare Earths Ltd.* The Company celebrated the completion of 25 years of its Rare Earths Factory at Alwaye (Kerala) in December 1977. The work on the first stage of its Orissa Sands Complex Project near Chhatrapur is in progress. There was a short-fall in the export turnover of the company during 1977-78 due to inadequate supply of monazite because of depletion of mineral sands reserves in the coastal mining areas at Manavalakurichi. A plant for recovery of helium as a by-product in monazite processing is expected to go into production shortly.

*The Electronics Corporation of India Ltd.* For 1976-77, the Corporation earned a net profit of Rs 32.64 lakhs and supplied approx. Rs 132.56 lakhs worth of instrumentation to various nuclear power and heavy water projects of the Department.

*Uranium Corporation of India Ltd.* At the Jaduguda Mine, the mine

# Modern Living Depends on Stable Materials[*]

IN the early days of human civilisation, materials available to man were limited, and the methods of production were relatively simple—utilising a few tools as well as some energy, usually solar, human or animal. With the advent of the Industrial Revolution, the range as well as quantities of materials required to support and sustain a single person increased greatly. It is estimated that today, in the USA, to sustain and transport a person of about 70 kg weight, it requires a per capita yearly utilisation of nearly 4½ thousand kg of sand and gravel, 850 kg of petroleum, 4,000 kg of stone, 2,300 kg of coal, 500 kg of iron and steel, and 1,200 kg of forest products, besides items of daily consumption like meat, milk, cereals etc. This indicates, in comparison to the small size of man, the huge demands made on the environment and on the total available natural resources. To meet these requirements, man has linked himself irrevocably with machines, to supply his daily needs, and for his transportation. The energy needs of modern man and his machines are met by converting the potential energy of coal, oil or the nucleus of the atom. To sustain him, various machines must be made of materials which are stable and usable in a very hostile and chemically reactive environment. The sustenance of civilisation, therefore, depends on the stability of these materials.

In this quest for stable materials an increasing number of complicated alloys are being developed, *e.g.* stainless steel, hostelloy, Incaloy, Inconel etc. Yet even these specially developed corrosion-resistant alloys corrode in environments containing traces of certain constituents. A classic case is the stress corrosion cracking of stainless steel in the presence of a few ppm of chloride. It was not until 1940 that this behaviour could be correctly explained. Prior to this event most of the cracking problems in stainless steel were attributed to fatigue or weld cracking, as it was inconceivable that mere traces of material in the environment could produce devastating failures.

As the engineers and scientists go about devising new materials, it becomes necessary to mention the famous Iron Pillar of Delhi which, though made of wrought iron, has withstood the rigours of climatic exposure over a thousand years, and has remained free of corrosion.

It is therefore essential that all-out efforts are made to solve material problems related to corrosion. It is recognised that corrosion, like cancer, is a very complex phenomenon. In fact it is a generic name which includes a variety of mechanisms and modes of damage. Hence I believe at some stage attention should be paid to the broad spectrum of materials which serve the needs of man, as every need of man e.g. housing, food, clothing, communication, transportation, energy, recreation, personal development etc. is satisfied by materials in one way or the other. I would like to stress the inclusion of even biological materials especially as there has been considerable advance in prosthetics in recent years. Some of these new substances are key materials for repair and for substitution of human organs and parts. Joints, for instance, can be replaced with polymers and ceramic and metallic materials. These materials must have special properties of mechanical and chemical stability. Further, the ions which are likely to be released in even minimal concentrations must not contribute to subsequent diseases. Conversely, these materials must not corrode in body fluids. Though materials are selected to meet man's different needs on the basis of cost, availability, aesthetics and other properties, all the materials have in common an inherent tendency to decay or corrode into the more stable form.

Because the interests of this symposium are pertinent to the fundamental process which relates to the stability of materials I am proposing that a special broad-based symposium on 'Materials in the Service of Man' be organised.

The Institution of Engineers could further also arrange, either on their own, or jointly with other insti-

(*Continued on page 12*)

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[*] Excerpted from an address by Dr. H. N. Sethna, Chairman, AEC at an All India Symposium on Corrosion organised by The Institution of Engineers (India) Bombay, on April 1, 1978.

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## *Annual Report 1977-78*

shaft was deepened from 315 m to a depth of 640 m. The ore body was intercepted at two levels with completion of cross-cuts from the shaft; development of ore has started.

### International Relations

For the 21st year in succession since the inception of the International Atomic Energy Agency, India was designated a member of the Agency's Board of Governors. This is based on India's position as one of the nine most advanced member-countries in the technology of atomic energy in the world. India has been actively participating in major discussions on peaceful uses of atomic energy, and in sharing knowledge in this area with developing countries. An Indian delegation led by the Chairman of AEC, Dr H. N. Sethna participated in the 21st regular session of the IAEA General Conference held in Vienna during September-October 1977. An Indian delegation also participated in the International Conference on Nuclear Power and its Fuel Cycle organised by IAEA at Salzburg, Austria in May 1977. India was also a participant in the International Conference on Transfer of Nuclear Technology, held at Shiraz, Iran in April 1977.

India continued to provide training facilities to foreign personnel nominated by the IAEA for training in this country under its Technical Assistance Programme, and to scientists from countries with whom bilateral collaboration agreements have been signed. ●

## Corrosion

*(Continued from page 11)*

tutions like the Nehru Centre in Bombay, to have a museum of materials, which could cover the entire spectrum of materials and their uses. There could be different categories or dimensions into which these materials could be distributed *e.g.* one dimension could represent metals, ceramics, aggregates, polymers, natural organic materials like timber, and cotton, and animal materials such as leather. It could also include materials for use in the human body *e.g.* bone, skin, cell and membranes. Another dimension could be the process by which these materials are converted from their available state to the state in which they are used by man. This could include process steps like refining, fabrication and final production, as also the whole life-cycle of materials—decay, waste forms and recycling. The third dimension could be the special properties like specific strength, lustre, magnetism, refractiveness and conductivity. This kind of organisation of materials would bring to focus qualities or properties based on which a material finds its application. It would also indicate conditions due to which a material decays or corrodes.

These varied applications of the materials in the service of man would serve another useful purpose—that of conservation. Once we recognise the materials that go into the per capita consumption of man in any society or in any environment, we would also be able to indicate how much of the material is additional, or normally redundant but required largely due to the fact that they corrode and have to be replaced. It would be worthwhile to look at corrosion from this angle and determine the saving in material if corrosion is reduced. ●

## Solar Still Commissioned at Avania Village

A DESALINATION plant based on solar energy was commissioned at Avania village, 11 km from Bhavnagar on March 5, 1978.

The solar plant was developed at the Central Salt & Marine Chemicals Research Institute (CSMCRI), Bhavnagar, and the entire construction and installation work was carried out by the CSMCRI scientists. The plant has a capacity to produce 5000 litres of product water per day. The plant consists of 90 stills, with a total evaporating surface of 1870 $m^2$. Avania village has no electricity, and the well water for community use is brackish and contains dissolved salts to the extent of 2750 mg/litre. According to WHO standard, the maximum permissible limits of dissolved salts and fluoride per litre are 1000 mg and 1.5 mg respectively.

The purpose of installing the solar still is two-fold, *viz* (i) to cater to the potable water needs of villages like Avania where no electricity is available; and (ii) to demonstrate the viability of such plants.

The Council of Scientific & Industrial Research made available a sum of Rs 2.5 lakh for installing the plant.

*(CSIR News)*

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## Low-Cost Unit for Defluoridation of Water

THE National Environmental Engineering Research Institute (NEERI), Nagpur, has developed a low-cost and easily adaptable method for defluoridation of water. The method is suitable for small communities ranging from 200 to 2,000 people. Based on the Nalgonda technique for defluoridation developed earlier by NEERI, the process involves adding of requisite quantities of alum, lime and bleaching powder in water of high fluoride content, stirring for a while and then allowing it to settle. The settled sludge is discarded and the supernatant used for domestic purposes.

In many parts of India, the problem of excess of fluorides in ground water is encountered. The permissible and excessive limits of fluorides in drinking water, as prescribed by the Union Ministry of Health and Family Welfare, are 1.0 and 2.0 mg/litre respectively. Consumption of water containing 1.5 mg/litre or more of fluorides, particularly during the first eight years of life, leads to dental fluorosis which is evident from the severe mottling of teeth. Ingestion of high fluoride through water over a period of 1-20 years results in crippling fluorosis and osteosclerosis. Calcification of certain ligaments renders movement of joints difficult and the individual becomes incapacitated.

*(CSIR News)*

**Nuclear India**
is a monthly publication of the Department of Atomic Energy, published around the 20th of each month. To ensure prompt attention, all communications should be addressed to the Editor, NUCLEAR INDIA, Department of Atomic Energy, Chhatrapati Shivaji Maharaj Marg, Bombay 400 039. While intimating change of address, the code and number given on the wrapper should be mentioned. Bombay recipients may contact 25 04 77 for prompt action.

To cover a large number of readers, NUCLEAR INDIA is being sent to major public libraries, university libraries and Government of India Information Centres. Interested readers are urged to contact these centres as we are not in a position to enroll names of individuals on its mailing list. NUCLEAR INDIA is also not available on subscription.

Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India, Chhatrapati Shivaji Maharaj Marg, Bombay 400 039, and printed by him at G. Claridge & Co. Ltd., Bombay 400 001.

Registered No. R. N. 9002/62

NUCLEAR INDIA

VOL. 16 No. 10 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY JUNE 1978

# Lithium Mass Spectrometer from Trombay

THE Technical Physics Division of the Bhabha Atomic Research Centre, Trombay, has recently designed and produced mass spectrometers for analyses of two isotopes of Lithium ($Li^6/Li^7$), and of hydrogen (D/H).

Mass spectrometry is an established technique for chemical and process control analysis in R & D units. The technique plays a vital role in atomic energy where it is used for heavy water analysis, reactor fuel burn-up studies, fuel accounting and isotopic separation, etc.

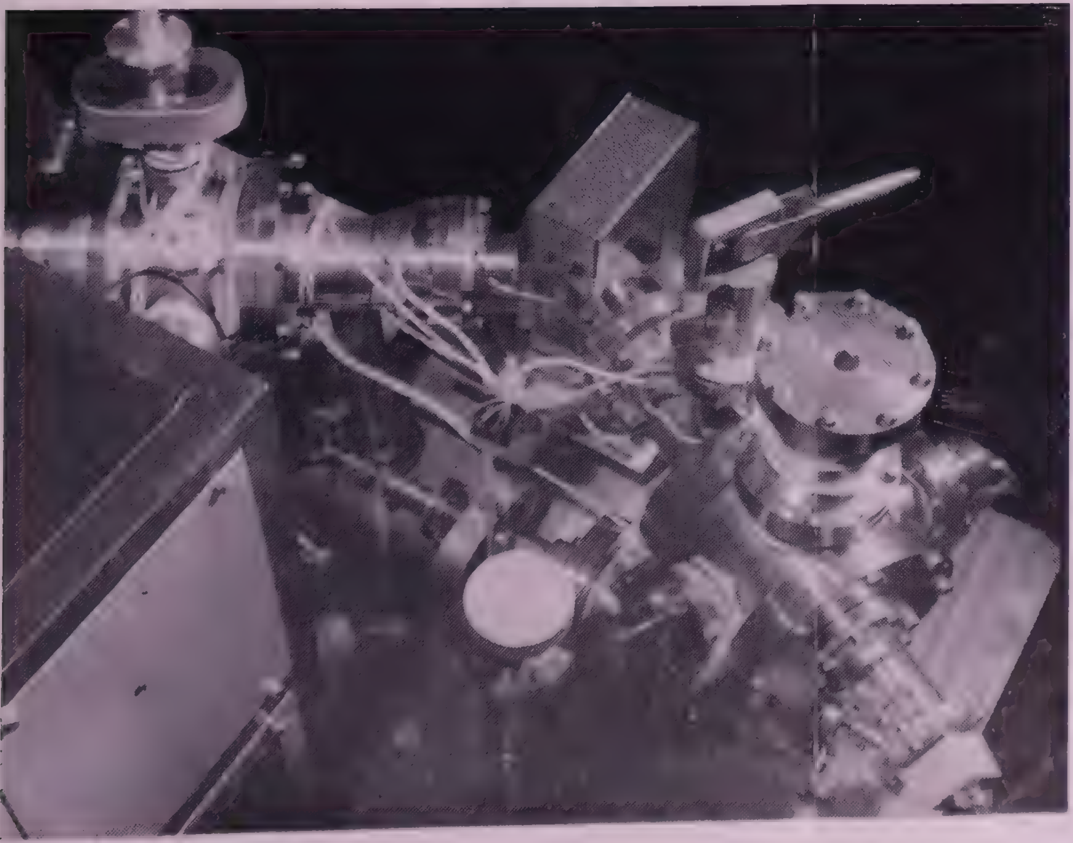
These mass spectrometers fall in the class of double collector systems where beams from two isotopes are collected simultaneously, and the electronic signals are processed to give the ratios directly on a digital panel meter.

**Radioisotopes in Soil, Fertilizer Studies, page 4**

The Lithium mass spectrometer uses a thermal ionisation source, magnetic sector analyser, and a double collector system, alongwith highly stable electronics.

A few microgram (in the range of 5μ **gm)** quantity of the sample in the form of lithium nitrate is deposited on the side filaments of a triple filament assembly, which is then loaded in the

*(Continued on page 6 )*



Top : **Fresh sample being loaded into the ion source.** Bottom : **Close-up view of the Analyser. Collector chamber with a gauge head, analysing magnet isolation valve and ion source chamber with cold thimble can be seen from left to right.**

# 'Common Safety Criteria Necessary Irrespective of Causative Agents'

**by Dr. A. K. Ganguly**
Director, Chemical Group
Bhabha Atomic Research Centre

IT is now generally realised that, in addition to ionising radiation (both natural and man-made), the human environment contains other important man-made agents which pose a threat to human health and well-being. Among such agents are non-ionising radiations such as microwaves, ultraviolet light, lasers and chemical compounds.

*Non-ionising radiation:* Microwave radiations are one example. With the advent of high power microwave generators and their application in radar, communication, broadcasting, medicine, industry and household appliances, there is a possibility of a large number of persons getting exposed to these radiations.

At high levels of exposure, microwave radiations are known to interact with body tissue, depositing their energy in the form of heat. These thermal effects are responsible for tissue damage and the lethal effects observed at high exposure levels (hundreds of milliwatts per $cm^2$). However, the effects of microwaves at low levels of exposure in the working and general environment are not well known. Western scientists argue that at low levels, the heat generated by microwaves in body tissue is so small that no undue effects are discernible. But scientists of East European countries have reported a number of adverse effects such as fatigue, headache, sleepiness, irritability, neurological problems, anxiety, behavioural changes etc which they attribute to non-thermal effects of chronic exposure to microwaves at low levels. Because of the fundamental differences in understanding the effects at low levels, there are significant differences in the levels of maximum permissible exposure to microwave radiation recommended by the two groups. The Western group (USA, UK, Canada etc) recommends a limit of 10 $mW/cm^2$ for continuous exposure, which can be raised to higher levels for shorter exposure periods. The East European group, on the other hand, recommends a limit of 0.01 $mW/cm^2$ for continuous exposure. These two levels differ by a factor of 1000.

*Toxic chemical compounds:* Man is exposed to a number of chemical compounds, in various concentrations, in the form of pesticides, herbicides, cosmetics, food additives, drugs, industrial solvents and effluents, rubber, plastics, automobile exhausts, heavy metals etc through air, water and food. There are obout three million chemical compounds in use today, and nearly 700 new ones are being introduced every year. Many of these compounds are produced in millions of tonnes per year and distributed throughout the world. Besides these compounds, effluents generated during manufacture are released in substantial quantities to the ambient environment.

The effect of exposure to these chemicals may vary from a mere skin irritation to malignancy. Epidemiological studies and laboratory experiments have established that many of these compounds are carcinogenic and mutagenic. For example, it is known that exposure to asbestos results in lung cancer; vinylchloride monomer causes liver cancer, nickel results in cancer of the lungs and nasal cavity, and cadmium causes prostate and respiratory cancers. The International Agency for Research on Cancer (IARC), has evaluated more than 270 chemicals for their carcinogenic risk to humans; of these, 20 were found to be associated with the occurrence of cancer in humans. For 15 of these 20 chemicals, exposure was solely or mainly occupational. Experimental evidence of carcinogenicity has been confirmed for 137 of the 270 chemicals considered. Evidence of human exposure exists for 131 of the 137.

## Prevention of Carcinogenic and Mutagenic Effects

General legislation which limit exposure to conventional toxic substances do not cover carcinogenic and mutagenic effects. This is in contrast to the situation existing in the control of ionising radiation hazards. Some estimates suggest that the potential hazards of even the recommended values are much higher than those accepted for ionising radiation. Quantitative data on the induction of malignancy and genetic damage at low levels of chemical exposures are not readily available, or available data have not been evaluated against a specific safety standard to be attained. Hence legislation in the production, distribution and use of carcinogenic compounds is very scanty. Indeed there are only 14 countries which have some legislation in this regard. Even in these countries the emphasis is more on providing monetary compensation than on primary prevention. The radiation protection effort has not contributed so far to the concept of monetary compensation or in any relaxation of efforts towards prevention of radiation hazards.

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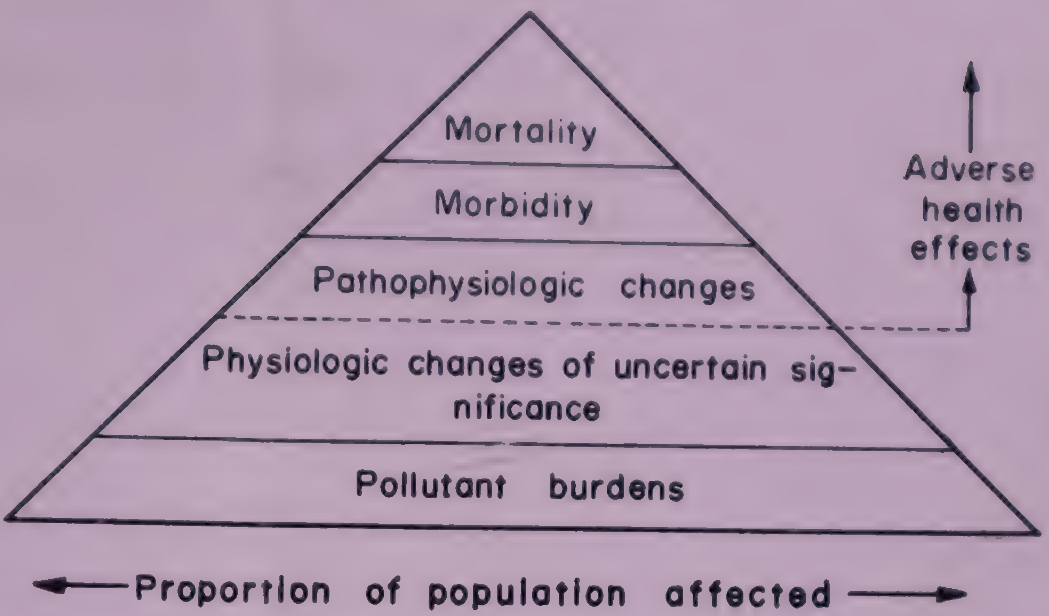
Based on the Bhabha Memorial Oration given by Dr. Ganguly at the Annual Conference of the Society of Nuclear Medicine, at Trivandrum in October 1977.

Spectrum of biological response to pollutant exposures.



Until now, the radiation safety scientists in the radiological and nuclear industries were preoccupied with radiation hazards only, and had not considered systematically the hazards of other agents, even in their own operational areas. They accepted the safety standards in vogue in the conventional fields. We know now that the stipulations are not all valid for ensuring human safety in this area. It is realised that the radiation hazards under the well-disciplined controlled conditions as obtaining today is only a very small fraction of the totality of hazards from other sources.

Our concern for setting up safety standards however, should appropriately encompass the total gamut of hazards, including carcinogenic and mutagenic, to Man from all sources in his environment, and to bring about an uniformity in standards. It is all the more important when we consider the ubiquitous nature of chemical pollutants, and the possibilities of synergistic action amongst chemicals on the one hand, and chemicals and radiation on the other. In the application of modern science and technology for human welfare, radiation safety scientists are placed in a situation of dichotomy in the nuclear industry where distinctly different standards are in force. One set of standards of long term objectives are applied to enforce radiation safety, and another set of standards of short-term objectives are applied to conventional hazards.

## Guidelines for Developing Common Safety Objectives

The problem is that of evolving uniformity of approach for developing criteria regarding acceptable risk and detriment, irrespective of the causative agents. A specific injury is an injury; a given hazardous situation is a hazardous situation, whether it is caused by radiation or otherwise. While the current practices in radiation health and safety take cognizance of the totality of radiation safety problems, including its impact on the environment, in the case of conventional hazards, the safety standards turn mostly towards safeguarding against somewhat immediate or acute health effects, including fatalities (see Fig.)

There are a number of lessons that have been learnt and a number of principles established in the process of setting up standards for radiation protection, which are worthy of emulation while setting up safety standards in the conventional fields.

The objectives of radiation safety is defined in the following terms: 'Radiation protection is concerned with the protection of *individuals, their progeny, and mankind as a whole*, while still *allowing necessary activities* from which radiation exposure might result'. Permissible environmental radioactivity levels evolved in different countries arise from these primary considerations of protection of Man, though without specific reference to the protection of other life forms, or protection of environmental resources for the economic exploitation, well-being and recreation of Man. However, it is believed that the radiation protection of other life forms in the environment have been indirectly accomplished through the efforts for safeguarding Man and his interests.

Experience in the peaceful exploitation of atomic energy indicates that no significant deleterious effects have been discernible even in the immediate neighbourhood of the site where radioactive wastes have been discharged for more than three decades in accordance with the prescribed limits, nor have there been occasions when these practices have prejudiced harvesting of environmental products by Man. I do recognise that certain profound controversies still exist on this issue, but it should also be recognised that no such statements can be made in respect of disposal of conventional pollutants into the environment. The examples of damage to the ecosystem and environmental economic products, and directly to Man himself from effluent discharges are too numerous and obvious.

In the non-radiation field also it is recognised that 'the health of Man is paramount'. Primary air and water quality standards have been established to protect human health from adverse effects attributable to air and water pollutants arising from multiple sources.

The aim of radiation protection is to prevent detrimental non-stochastic effects even to individuals, and to limit the probabilities of stochastic effects to acceptable levels. The prevention of non-stochastic effects is achieved by setting dose limits at

*(Continued on page 7 )*

# Radioisotopes in Soil, Fertilizer Studies

**by T. J. D'Souza**
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AROUND 170 million hectares of land are devoted to food crops in India. The soil that supports these crops in many parts of the country is often depleted of nutrients because of continuous cultivation over a period of years. Dearth of cultivable land makes the use of fertilizers (in addition to good irrigation) essential for increasing production. It is estimated that the productivity due to one tonne of fertilizer is equal to the average yield of two hectares. Application of fertilizers is therefore recognised as the quickest means of increasing productivity of land. In the national strategy for increasing agricultural production, fertilizers naturally occupy an important position.

Because of widespread deficiency of nutrients in the soil in India, the demand for fertilizers is very much higher than what is available. In other words, the use of fertilizers in the country is much less than what is really needed by the soil.

The application of commercial fertilizers in India has of course increased over the years. In 1960-61, it was a mere 0.5 million tonnes, while in 1977-78, it rose to more than 4.0 million tonnes. It is estimated that 20 kg. of nitrogen/phosphorus potassium is currently being applied per hectare per year through chemical fertilizers, compared to 400-700 kg. per hectare per year in Japan and the Netherlands.

Upto November 1977, there were 22 nitrogenous and complex fertilizer plants and 32 phosphatic units operating in the country. Though production of fertilizers has been rising, the cost also has continued to remain high due to the increasing price of imported crude, and the paucity of local rock phosphate. These factors therefore rule out any reduction in fertilizer prices in the near future.

A good crop yield also results in depletion of nutrients from the soil to a considerable extent. More than 100 kg. each of nitrogen and potassium are estimated to be removed from one hectare of agricultural land by a good wheat crop. And, although phosphorus depletion is relatively less (100 kg. $P_2O_5$ from an hectare) its utilization by a crop is only about 20 per cent of the quantity applied to the soil. Besides depletion of these major nutrients, deficiency of micronutrients, especially of zinc, have also been reported in various parts of the country.

The introduction of new high yielding varieties has resulted in raising the requirement of fertilizers. As the money for buying fertilizer may often be the farmers' only cash outlay for a crop, there could be considerable strain on his resources. It is therefore necessary to ensure that fertilizer use is efficient and brings in maximum benefit. Detailed research is thus required for arriving at proper guidelines in fertilizer application to different crops on different soils.

It is in this area that radioisotopes are proving invaluable to the agriculturists for they have come to play a vital role in fertilizer research leading to assessment of a wide spectrum of soil fertility problems. Research programmes relating to fertilizer use, soil fertility and soil-plant relationships of nutrients, undertaken with the use of nuclear techniques are helping in obtaining precise information on these aspects and can lead to optimum utilisation of fertilizers.

Isotope techniques have proved of immense value in studies aimed at gaining information on the complex relationships existing between the soil and the mineral nutrition of plants. Since the nutrient requirement of crops varies considerably with the soil, climatic conditions and plant species, precise knowledge is required on the type, amount, method and time of application of fertilizer materials best suited for specific soil-crop combinations.

Use of isotope labelled fertilizer materials permits such determinations and reveals directly, within weeks, information which otherwise can be deduced only after many years of elaborate yield studies and which is, even then, not as reliable.

## *Evaluating Phosphatic Fertilizers*

Since many soils are deficient in phosphorus, it is important to compare the content of phosphorus in fertilizers of different chemical forms. In this work the radioisotope P-32 has proved of great value; it has

Table I—**Requirements of labelled agrochemicals—1978**

| S. No. | Field of study | Products | Quantity per year |
|---|---|---|---|
| 1 | Fertilizers and soil plant relationships | (*a*) P-32 labelled superphosphates | 100 Kgs |
| | | (*b*) P-32 labelled nitrophosphates with varying water solubilities | 100 Kgs |
| | | (*c*) P-32 labelled ammonium phosphates | 10–20 Kgs |
| | | (*d*) Other calcium phosphates (Ca-45 and P-32 labelled) | 10–20 Kgs |
| | | (*e*) P-32 labelled polyphosphates | 5–10 Kgs |
| | | (*f*) N-15 labelled ammonium sulphate, urea and nitrophosphate | 5–10 Kgs each |
| | | (*g*) Labelled inorganic salts (Ca-45, S-35) | 1 Ci each |
| 2 | Micronutrients | Labelled inorganic salts (Zn-65, Mn-54, Fe-59, Co-58) | In curie amounts. |

enabled investigators to detect differences with a precision unmatched by any other method. In view of the urgent need for objective evaluation of several conventional and newly developed phosphatic fertilizers for food crops in Indian soils, a project on these aspects was organised by the BARC during 1974-76. The grades of ammonium nitrate phosphates included for study under the project covered 30-70 per cent water-soluble phosphorus content. The tri - and tetra ammonium pyrophosphates, which are the major constituents of newly developed ammonium polyphosphate fertilizers, and mono- and diammonium orthophosphate fertilizers were the others included in the study. All the required isotope labelled products were supplied by the BARC.

The Biology and Agriculture Division of BARC was associated in the project with the Central Rice Research Institute, Cuttack; the Andhra Pradesh Agricultural University, Hyderabad; Punjab Agricultural University, Ludhiana; Fertilizer Corporation of India (Sindri and Trombay units), and the University of Udaipur. These institutions are located in areas covered by red soil, laterites, medium and deep black soils, coastal alluvium, calcareous alluviums and sierozems of alluvial origin. Uniform greenhouse and field trials with rice, wheat, maize and sorghum crops were conducted at these institutions. Isotopic tracer techniques using $^{32}$P-labelled fertilizers enabled the evaluation of relative efficiency of the phosphate sources on the basis of isotopic tracer data in terms of per cent phosphorus in plant derived from fertilizers, per cent utilization of applied fertilizer, 'A' value and Effective Rate of Application, in addition to conventional parameters of dry matter and grain yield, and total phosphorus uptake.

Table II—**Radioisotope labelled products being prepared at Primary Isotopes Section, Isotope Group, BARC**

| S. No. | Product | Code |
|---|---|---|
| 1 | Calcium hydrogen phosphate P-32 | PHS-1 |
| 2 | Calcium dihydrogen phosphate P-32 | PHS-2 |
| 3 | Disodium phosphate P-32 | PHS-3 |
| 4 | Orthophosphoric acid P-32 | PHS-5 |
| 5 | Sodium dihydrogen phosphate P-32 | PHS-8 |
| 6 | Sodium pyrophosphate P-32 | PHS-9 |
| 7 | Single superphosphate P-32 | PHS-10 |
| 8 | Ammonium dihydrogen phosphate P-32 | PHS-17 |
| 9 | Diammonium hydrogen phosphate P-32 | PHS-18 |
| 10 | Triple superphosphate P-32 | PHS-32 |
| 11 | Ammonium nitric phosphate P-32 grading $N_2$: $P_2O_5$: $K_2O$ = 20:20:X water soluble $P_2O_5$ content 5–95% | PHS-33 |
| 12 | Single superphosphate P-32 (in gelatine capsules) | PHS-34 |
| 13 | Triammonium pyrophosphate P-32 | .... |
| 14 | Tetraammonium pyrophosphate P-32 | .... |
| 15 | Tricalcium phosphate P-32 | .... |
| 16 | Calcium carbonate Ca-45 | .... |
| 17 | Gypsum Ca-45 | .... |
| 18 | Gypsum S-35 | .... |
| 19 | Ammonium sulphate S-35 | .... |

The major research findings of the project indicated that all the fertilizers studied were equally efficient for rice grown on acidic red soils, acidic coastal alluvial soils, and highly calcareous soils. In the case of the other soils studied, fertilizers having higher water soluble phosphorus were efficient. The results also demonstrated the potential of the new pyrophosphates: tri- and tetra ammonium pyrophosphates, which are the major constituents of ammonium polyphosphate fertilizers, for cereal crops on principal Indian soil types. These water soluble ammonium polyphosphate fertilizers are of special interest in view of their high phosphorus and nitrogen content, which provides more nutrient per unit weight of the fertilizer, and lower cost of handling, transport, storage and application in the field. The results underline the need for further intensive studies to assess the suitability of ammonium polyphosphates for diverse soil-crop complexes of our country.

*(Continued on page 6 )*

# *BARC, Leading Supplier of Labelled Fertilizer*

*(Continued from page 5 )*

### *Micronutrients*

With the intensive use of high analysis nitrogenous and phosphatic fertilizers, the role of micronutrients assumes great importance. The physicochemical and edaphic factors governing the transfer of the above micronutrients from contrasting Indian soils to plants are presently under investigation at Trombay.

Some of the essential plant micronutrients have a tendency to become immobilized, or fixed in soil and thus are not available for plant growth. Other nutrients, notably nitrogen, may travel rapidly following the water movement. Isotopes have been useful in studying the movement of such nutrients through the soil. This is done by labelling the nutrient and applying it to the soil, then sampling the soil and measuring radioactivity as a function of sample location. At the BARC, the movement of labelled micronutrients zinc-65, manganese-54, iron-59 and cobalt-58 has been studied after surface application on a black clay loam soil and a laterite. All the four micronutrients were found to be immobile when leached with rain water, or moderately high calcium or sodium irrigation waters in both the soils. However, on leaching with synthetic chelating agents like ethylene-diaminetetracetic acid, rapid mobility of all the four micronutrients was observed.

### *Promoting Research in Soil Fertility*

The Department of Atomic Energy places high priority for research on the use of isotopic tracer techniques in soil fertility and fertilizer studies. Besides organising work in its own research centres, the Department also supports research in a number of universities and research institutions by way of grants and technical assistance. Towards this end, the Department made a modest beginning with the development of radioisotope labelled agrochemicals in the Isotope Group of BARC as early as 1962 when a specific request for the supply of 10 kilograms of $^{32}P$ superphosphate was made by the Indian Agricultural Research Institute, New Delhi. Since then, a variety of radioisotope labelled fertilizers such as superphosphate, nitrophosphate with varying water solubility, tri- and tetra ammonium pyrophosphates, calcium phosphates, ammonium sulphate, etc. labelled with isotopes like $^{32}P$, $^{45}Ca$ and $^{35}S$ have been supplied by the Isotope Group. In addition BARC is also supplying primary isotopes like—$^{65}Zn$, $^{54}Mn$, $^{59}Fe$, $^{58}Co$, $^{99m}Mo$, etc. to various agricultural institutions for their micronutrient research programmes.

The present requirement of labelled agrochemicals in the country is met entirely by the Isotope Group of BARC (Table 2, page 5). The output may have to be doubled in the course of the next five years to meet the increased demands for isotope-labelled agrochemicals in the country.

With the experience gained over years in the development and supply of various radioisotope labelled fertilizers, BARC has become one of the leading suppliers of these products. Trombay-produced labelled agrochemicals have been successfully employed in a number of agricultural research study programmes sponsored by IAEA in various countries. The countries to which the products have been exported include Austria, Bangladesh, Brazil, Italy, Lebanon, Morocco, Malaysia, Nigeria, Peru, Singapore, Sri Lanka, Syria and Turkey. ●

# *Mass Spectrometer from BARC*

*(Continued from page 1 )*

ion source chamber. The ion source is evacuated (using a fast vacuum system) and the sample heated by a filament current programmer. The ions emitted by the filament are extracted. As the ions pass through the magnetic field, the beams are separated according to the mass-to-charge ratios. The two isotopes of lithium appearing at masses 6 and 7 are collected and the signals processed, using highly sensitive ion current amplifiers. The ratio can be directly obtained using a precision null detector, or displayed on a digital meter.

The instrument built at BARC is capable of measuring $Li^6/Li^7$ ratios in the range 0.01-25 (natural lithium has a value of 0.08) with a precision of 0.5 per cent. The average duration of analysis is 80 minutes, and time taken for sample changeover is less than 10 minutes. About 5 samples can be analysed in an 8-hour shift.

The instrument has been in use for several months at Trombay where it has given excellent results. The estimated cost of the spectrometer is Rs 5 lakhs, against Rs 7 lakhs of an equivalent imported instrument. ●

# Hazards

*(Continued from page 8 )*

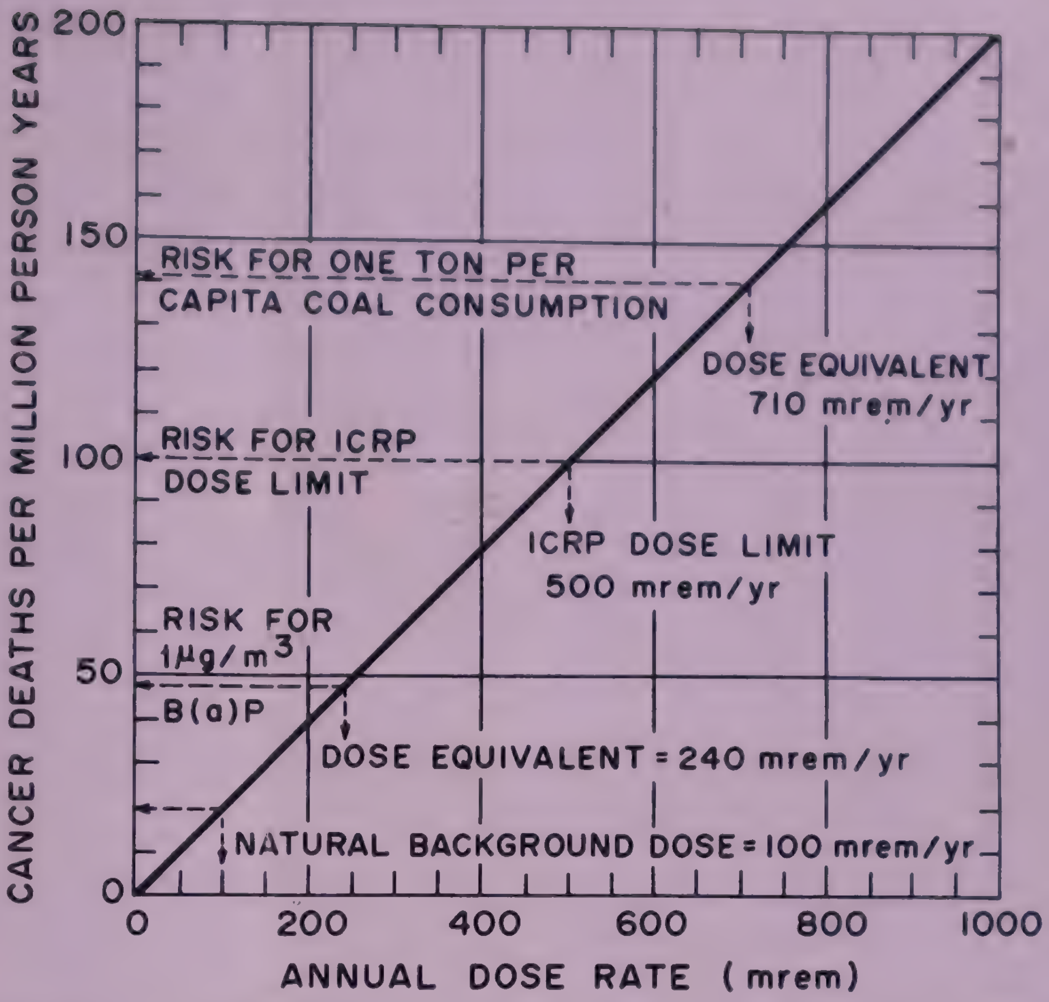
endosteal cells and epithelial cells on bone surfaces. Radio-sensitivity of bone in relation to the development of radiation induced cancer indicates that it is much less sensitive than breast, red bone marrow, lung and thyroid.

(8) *Children and foetuses*: Exposure before birth or during childhood may interfere with subsequent growth and development, depending on factors such as dose and age at irradiation. Susceptibility to the induction of certain malignancies also appears to be higher during the prenatal and childhood periods than during adult life. ●

# *Radiation Risk*

*(Continued from page 3)*

sufficiently low values so that no threshold dose would be reached even following exposure for a lifetime, or for a total period of working life. The additional requirement of limiting the stochastic effects is achieved by keeping all the justifiable exposures to the lowest level achievable. In the conventional field, the injuries considered are of non-stochastic type, although some considerations are now emanating for stochastic injuries (genetic and somatic), but not practised. In a very recent attempt at BARC the somatic stochastic effect like cancer induction by chemical toxins was considered. From the statistics collected in different countries the radiation dose equivalents of two conventional polluting agents were correlated (see figure.)



**Graphic representation of the cancer risk of radiation exposure, based on BEIR committee report. Dose equivalents for lung cancer risk of power from coal burning and risk of benzo (a) pyrene are also shown**

Some elaborate efforts have been made in the United States to identify the areas of ignorance on data base for understanding the risk equivalents of some conventional toxins like sulfur dioxide, carbon monoxdie, oxides of nitrogen, dust particles etc. in air. In asking what should a minimal adequate health-intelligence base assess, the researchers state that the base should ascertain the effects of long-term low level exposure and the effects of single or repeated short-term exposures. It should be remembered that the acute effects may be attributed to the cumulative effects of long-term low level exposures as well as to the effects of short-term peak exposures. This is essentially because the exposure response functions for the diverse effects are not available. It is further assumed in the estimation of risks that a threshold exists for each type of detriment associated with different toxins.

The safety measures that are being talked about for setting up standards for conventional pollutants are invariably based on information collected on exposure thresholds, which rely heavily on systemic recovery mechanisms in the exposed person. These effects do not indicate whether a permanent or long-lasting damage builds up when persons are continuously exposed to levels below the exposure threshold, although it is recognised that long-term low level exposures may lead to an acute effect similar to that of short-term exposures at a level below the prescribed exposure thresholds.

### Epidemiological Data Base and Extrapolation

In formulating its earlier standards of radiation protection, the International Commission on Radiological Protection (ICRP) relied heavily on extrapolation of data from animal experiments to Man. Primary standards were set initially on the basis of a few human exposure histories, like those of the uranium mine workers, radium dial painters, and experiences of early radiologists. The totality of human experiences on hazards from radiation exposure was extremely limited. I would consider that the totality of human experience with conventional pollutants have been at any point of time much more elaborate than radiation exposure. The extrapolation methodology of the ICRP to arrive at numbers can be questioned at many points. However, that was the best that could be done within the framework of the then existing knowledge. This methodology may as well, where needed, be adopted extensively in the conventional field. The present-day epidemiological data on radiation effects are based on the studies of the Atomic Bomb Casualty Commission in Hiroshima and Nagasaki and a number of published radiological surveys and radiation effects. In the conventional field there is extensive information available, and it should be feasible to collate the published demographic data on the effects of many of the conventional pollutants and hazardous industries, *e.g.* Pochin studied the fatality data from the Chief Inspector of Factories in UK

*(Continued on page 8)*

**Statistics of conventional injury and radiation exposure in BARC during 1966-1975.**

| Year | No. of employees | No. of disabling injuries | No. of mandays lost | No. of radiation workers | No. of persons exceeding 5 rem/y |
|---|---|---|---|---|---|
| 1966 | 9,500 | 85 | 963 | 2,951 | 16 |
| 1967 | 9,800 | 53 | 903 | 3,067 | 5 |
| 1968 | 10,110 | 45 | 866 | 3,082 | 6 |
| 1969 | 10,540 | 58 | 844 | 3,102 | 15 |
| 1970 | 10,727 | 55 | 743 | 3,295 | 5 |
| 1971 | 10,968 | 41 | 603 | 3,476 | 2 |
| 1972 | 11,140 | 60 | 997 | 3,456 | 3 |
| 1973 | 11,290 | 68 | 988 | 3,250 | 1 |
| 1974 | 11,420 | 40 | 533 | 3,083 | 1 |
| 1975 | 11,740 | 49 | 999 | 3,182 | 2 |

# *Safety Criteria*

*(Continued from page 7 )*

and arrived at the mean death rate for different industrial operations.

One of the most significant contributions of the ICRP to the science of safety has been the stipulation of permissible concentration to conform to the basic safety standards for the host of radioisotopes that are generated in the atomic energy industry. It brought about an admirable international discipline in setting up acceptable limits and safety standards in nuclear operations. Although power reactor operation and irradiated fuel reprocessing facilities deal with concentrated radio-toxins in astronomical quantities, it is gratifying to see that there has not been a single death in the nuclear power industry in the last decade that is attributable to radiation exposure. Further, the radiation dose received by the population due to atomic energy operations is only in the range of a few per cent (3 per cent in UK) of the natural background radiation. This will result in an estimated cancer death rate of 0.0045 to 0.006 in a population of 10,000. This can be compared with the cancer death rate in the chemical industry which ranges from 10-30 per 10,000 workers. Moreover, there is no international agreement in establishing permissible levels of exposure to chemical pollutants. All these are cited as a plea to the radiation medicine scientists and radiation safety scientists (i) for evaluation of global information that is available, (ii) to develop cogent concepts of acceptable risks and detriments, (iii) to evaluate, and extrapolate where necessary, and evolve a prescription for permissible levels for hazardous materials in the environment where Man lives and/or works.

*Tissue at risk:* As examples of assessment of relative radio-sensitivity of glands and tissues, we may ponder the following and urge the toxicologists to make such assessments for conventional toxins and hazardous materials.

The earlier ICRP concept of critical organ did not permit the summation of detriment according to relative radio-sensitivities of the irradiated tissues. The commission now recommends a procedure which takes ac-account of the total risk attributable to the exposure of all tissues irradiated. The following organs and tissues are considered because of their susceptibility to radiation damage:

(1) *Gonads:* The most important effects are impaired fertility and hereditary effects. These effects are age-dependent in women. Reduction of fertility may be temporary in man at low doses.

(2) *Red bone marrow*: Red bone marrow is taken to be the tissue mainly involved in the causation of radiation induced leukaemia. Radiation induced leukaemia reaches its peak value within a few years after irradiation, and returns to pre-irradiation levels after about 25 years.

(3) *Lung*: Cancer of the lungs has been observed in miners exposed to high concentrations of radon and its decay products. There is evidence that external irradiation can also induce lung cancer in man. The present indication is that the risk of lung cancer is about the same as that for development of leukaemia.

(4) *Pulmonary lymphoid tissue*: A particular case of importance concerns the retention of inhaled particles containing insoluble compounds in broncho-pulmonary lymph nodes, which comprise about 1 per cent of all the lymphoid tissue in the body. Selective irradiation of lymph nodes can be considered as corresponding to extremely non-uniform irradiation of the lymphoid tissue and hence has a lower hazard factor. Since the lung is regarded as of higher sensitivity than the lymphoid tissue, irradiation of lung is likely to be more limiting than that of lymphoid tissue.

(5) *Thyroid*: The cells exposed to risk in the thyroid glands appear to be the epithelial cells of the thyroid follicles. The sensitivity of thyroid to the induction of cancer by radiation appears to be higher than that of the red bone marrow to the development of leukaemia. However, mortality from thyroid cancers is much lower than that from leukaemia primarily because of the success in the treatment of cancer, and the slow progress of this type of tumour.

(6) *Breast:* Data on development of breast cancer following irradiation of women suggest that during reproductive life, the female breast may be one of the more radio-sensitive tissues of the human body. The risk factor for breast cancer may be a few times higher than that for leukaemia.

(7) *Bone*: The radio-sensitive cells in bone have been identified as the

*(Continued on page 6 )*

Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India,
Chhatrapati Shivaji Maharaj Marg, Bombay 400 039, and printed by him at G. Claridge & Co. Ltd., Bombay 400 001.

**Registered No. R. N. 9002/62**

NUCLEAR INDIA

VOL. 16 No. 11 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY JULY 1978

***R & D Work at BARC***

# Preventing Atmospheric Pollution from Nuclear Installations

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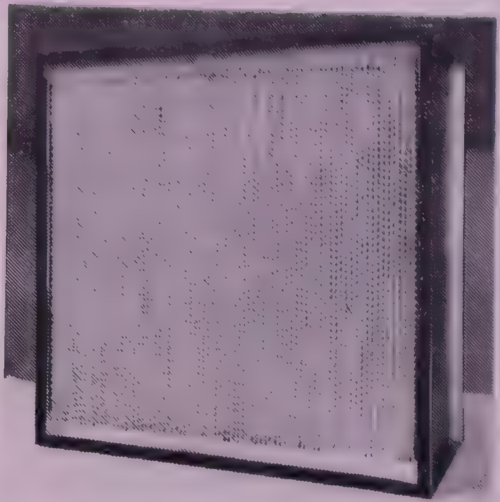
Bhabha Atomic Research Centre

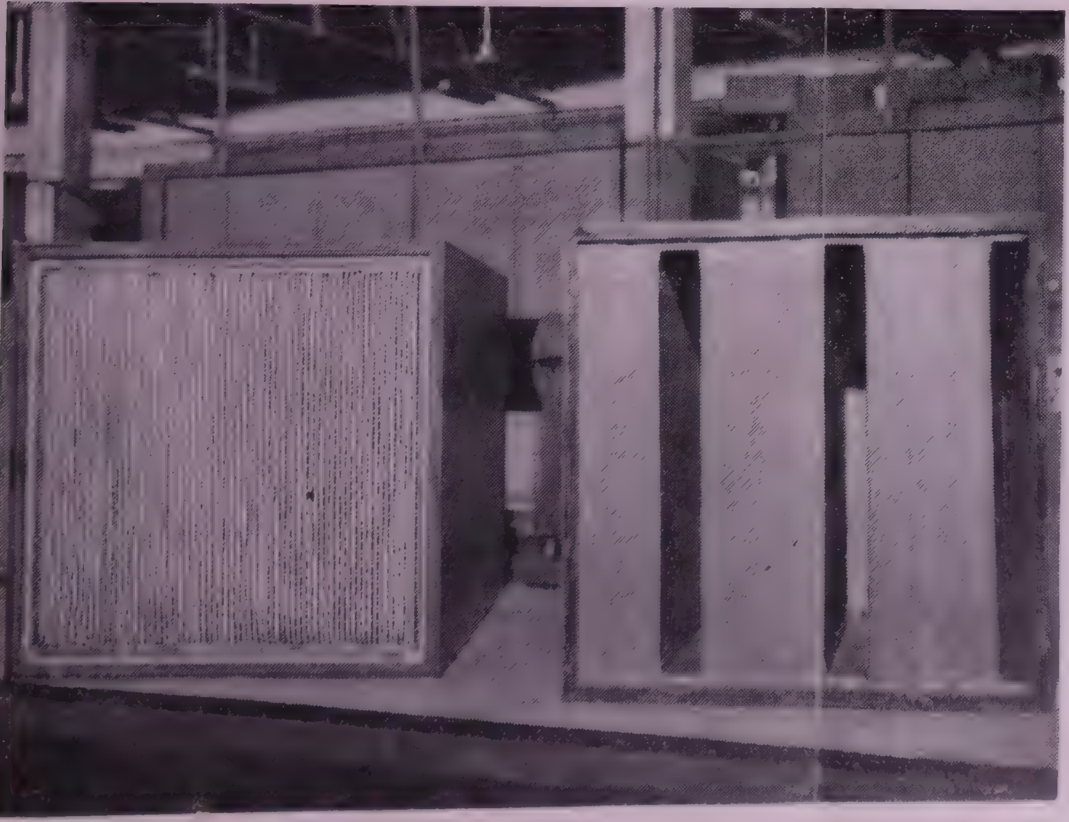
PARTICULATE and gaseous pollutants in air have always been an industrial problem. In the nuclear industry especially, even small concentrations of radioactive aerosols and gases leaking into the environment can pose serious hazard to personnel. In conventional industries, particularly in those where high purity materials are prepared, or where precision mechanical and electronic appliances are fabricated, it is imperative that the air in the working place is absolutely free from particulate matter and reactive gases. In the pharmaceutical factories, in the processing of many biomedical products even airborne viruses and bacteria have to be removed from the working place atmosphere.

In recent years public awareness of the dangers to health from air pollution has grown. Public acceptance of the nuclear industry today depends very much on the assurance that the industry provides of maintaining high safety standards and of ensuring an environment free from radioactive pollution. Because of the fear of the long-term genetic effects of radioactivity in the environment, the permissible limits for release of radioactivity have been made stringent, and accordingly the means for cleaning radioactive effluents have been made extremely efficient. As the number and capacity of nuclear plants are expected to increase and, consequently, the dilution capacity of the environment is proportionally reduced, the discharge limits of radioactive materials from individual plants will have to be brought down progressively. For this purpose increasingly sophisticated effluent control technology must be made available.



**HEPA filter : standard unit**

**Combined Particulate and Radioiodine filter**



This ultimate situation had been anticipated in India. Very early in the Indian nuclear programme the need for systematic R & D effort for evolving a technology for preventing atmospheric pollution from operating nuclear plants was realised and work had been initiated. By 1960, a group of engineers and scientists was already engaged in setting up a laboratory for this purpose. Within a decade a good number of specialists became available to work on developing advanced concepts and systems in this area. In 1974, an Air Cleaning Engineering Research Section was set up

*(Continued on page 2)*

# *Trombay-developed Filters Find Wide Application*

*(Continued from page 1)*

at the Bhabha Atomic Research Centre for consolidating and organising R & D work in this field.

Long before work commences on the construction of a nuclear plant at any location, an extensive study is carried out in the area to assess all possible effects on the population and the general ecology around the plant location of a possible release of radioactivity. A very high degree of built-in safety is also provided in individual plants to contain radioactivity releases within the plant enclosure under normal, as well as possible accident conditions. The most important of these containment systems are those required for preventing release of radioactive gaseous effluents.

In nuclear plants, airborne radioactivity, like conventional pollutants, exists in two main physical configurations *viz.* particulate matter, and gases and vapour. Basically, the methods used for removing particulate matter and gases are very different in concept and mechanism.

Particulate matter is the major source of activity release from nuclear plants. Conventional particle removal techniques have been found inadequate because the particles are mostly of very fine size *i.e.* in the submicron range. Besides this constraint the minimum removal efficiency required is also very high because of the very low release limits.

The first notable R & D programme started at BARC in the early Sixties was the development of HEPA filters (High Efficiency Particulate Air Filter). Another important and parallel programme that was started at the same time was on the development of filter testing methods, both for individual as well as filter bank installations in nuclear plants, for their collection efficiency against a standard submicron aerosol.

These programmes include basic aerosol filtration research, selection and processing of raw filter materials and development of filter units and testing procedures. The different systems developed at BARC cover various types of HEPA filters to meet different operating requirements in nuclear plants and laboratories.

After the development of these products, the question of commercial scale production was taken up as considerable demand had been built-up for HEPA filters in other industries. Technical knowhow for manufacture of HEPA filters was therefore transferred to private industries for large-scale production. Today, HEPA filters have large scale applications in the electronics, pharmaceutical and other industries.

Under certain unusual conditions where air streams are loaded with moisture, corrosive fumes, and contaminants of high specific activity, and where shocks and exposure to high temperature are also possible, special filter systems are required. To meet these needs a development programme was started for evolving suitable concepts for air filteration studies on sand beds. Work is now on at present to develop sand-bed air filters for specific purposes such as off-gas filtration in fuel reprocessing plants, and emergency air cleaning systems in fast breeder reactors.

### Gaseous and Vapour Pollutants

Activity in gaseous and vapour form is due to the various isotopes of gaseous fission products such as krypton, xenon and iodine. Most of these products are released in the fuel reprocessing stage of the fuel cycle, although, due to fuel element failure, some of them find their way to the environment in nuclear power plants also.

For removal of airborne radioiodine, solid adsorbers were found to be more efficient compared to liquid scrubbers. A number of adsorbents were developed for removal of radioiodine from gas streams; and activated charcoal filters were developed for removal of airborne radioiodine. This research programme included selection of activated charcoal, and design of a filter cartridge for use in nuclear power reactors. A method has also been developed to test these filters. The filters are currently being supplied to all the power reactors for use in emergency air cleaning systems.

The inherent disadvantage of activated charcoal is that it may be a possible fire hazard. Another important factor is the adsorption of radioiodine on the activated charcoal, partly physically and partly chemically. The physically adsorbed iodine may desorb due to overheating of activated charcoal by radioiodine decay heat if the concentration of iodine is high. Hence, at very high concentrations of airborne radioiodine as well as in the hot gas streams, inorganic solid adsorbents like silver exchanged molecular sieves were preferred. The adsorption of radioiodine on this material is mostly through chemisorption. This type of material is also very useful in off gases of fuel reprocessing plants where the long-life iodine-129 is to be trapped and contained almost permanently.

The radioactive noble gas fission products (radioisotopes of krypton and xenon) may get released from a boiling water reactor during normal operating conditions. Most of the radioisotopes are short-lived, except Kr-85 which has a half-life of 10.76 years. Delaying release of these radioisotopes to the atmosphere was considered to be a satisfactory mode of their control. Activated charcoal under low flow rates of dry gas streams was found to serve as an efficient adsorber for this purpose. BARC has designed and tested this process on a pilot plant scale. The process also includes a hydrogen elimination stage, a molecular sieve dryer for removal of moisture, and activated charcoal columns for dynamic adsorption of krypton and xenon.

Only krypton-85 and iodine-129 from the spent fuel is released during fuel dissolution in the fuel reprocessing plant, because, during the cooling

# n Industry

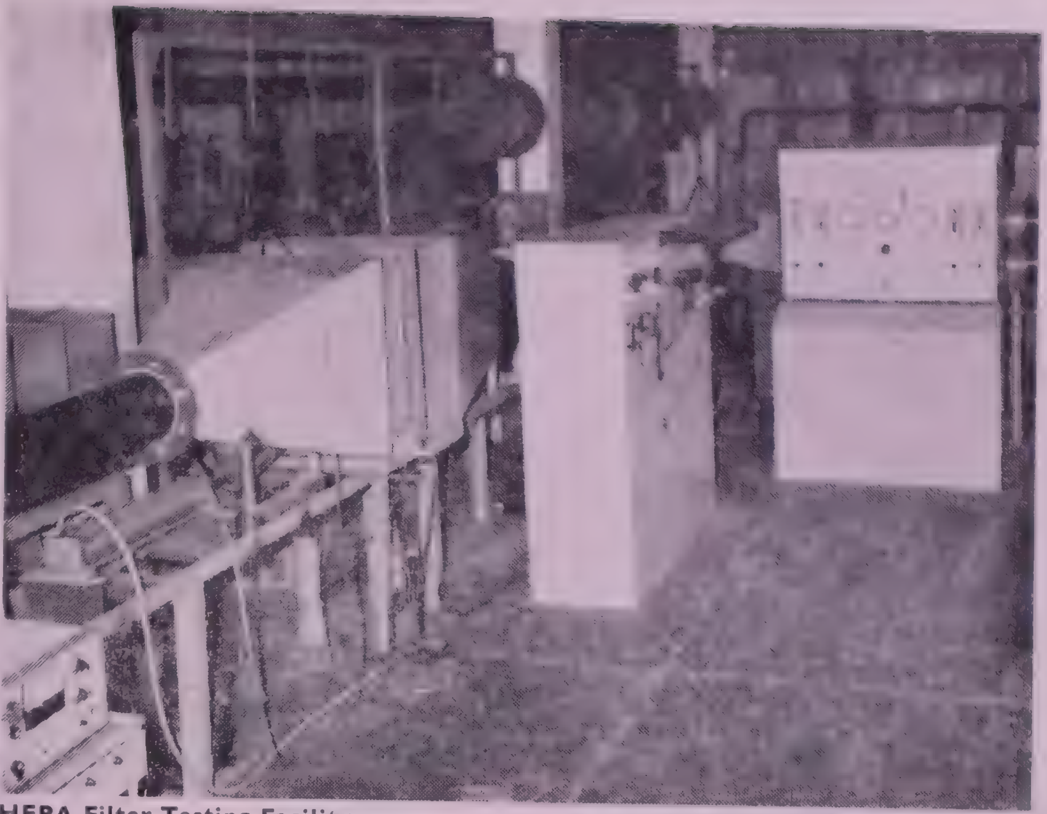
period, all shortlived radionuclides get decayed. BARC is currently considering a means of containing Kr-85 by using methods of enriching Kr-85 by an adsorption-desorption process followed by fractional distillation of liquified off-gas.

As an extension of the development of the HEPA filter medium and radioiodine filters, BARC has developed air sampling filter media for sampling particulate matter as well as radioiodine. The particulate sampling media are made from glass fibres, while the radioiodine sampling medium contains powdered activated charcoal in addition to the fibres.

The heavy water moderated nuclear reactors utilise inert gases like helium as cover gases in the reactor calendria. To maintain the purity of the moderator the cover gas has to be constantly purified. Normally, such a cover gas clean-up system utilises cryogenic adsorption of impurities like nitrogen on activated charcoal. BARC is currently engaged in developing an alternative and a more economical and efficient process which incorporates $H^2$ - $O^2$ combination, a molecular sieve drier and cryogenic adsorber unit. This type of cover gas clean-up system will be used in the R-5 reactor.

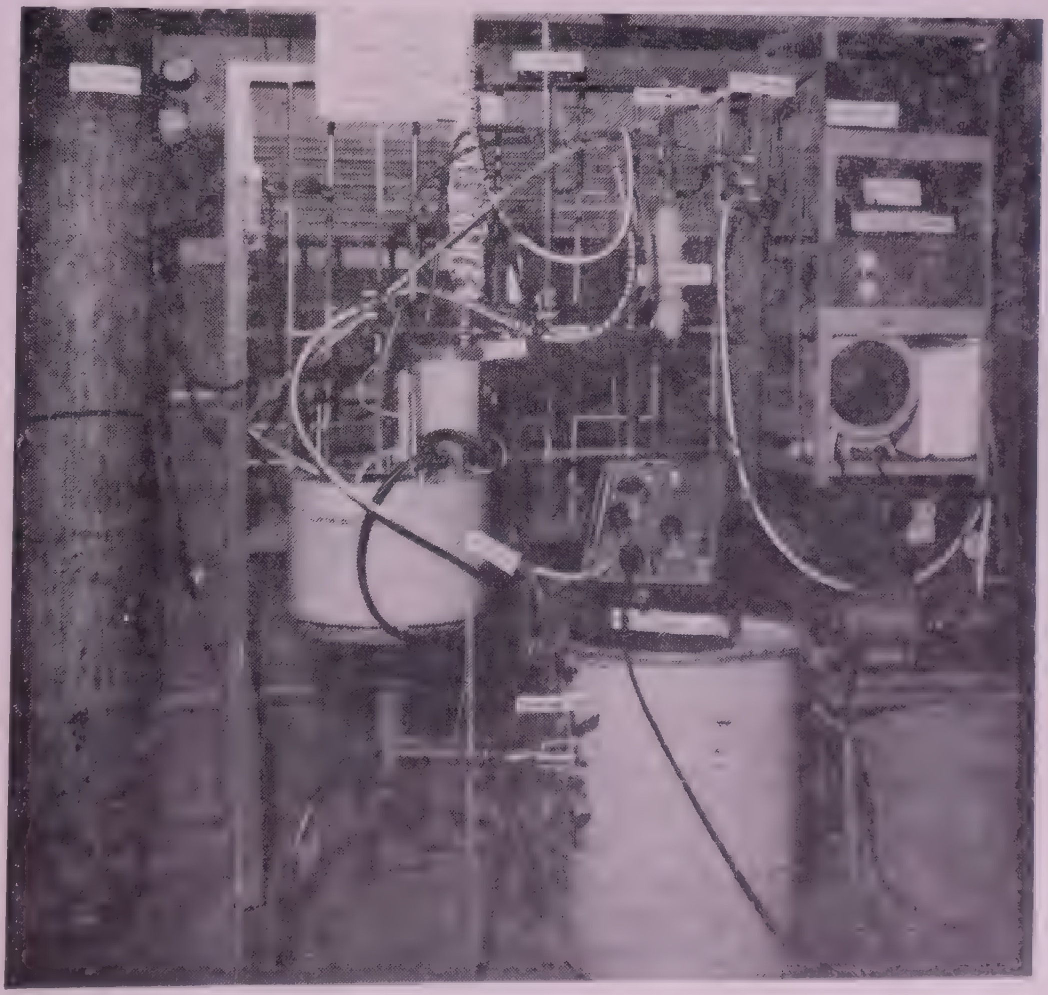
Air cleaning has developed into a discipline in itself in the nuclear industry because of the high priority given to contaminant removal, the need for quick removal of spent filters from filter banks, and handling of radioactive materials. Despite this specialisation, the requirements in pollution control mechanisms are more or less similar in both the nuclear and conventional industries. In some of the industries where the toxic levels of the material being handled are very low, and in others where high levels of cleanliness of the operational atmospheres are of utmost importance, most of the concepts and equipment developed for use in nuclear installations can be adopted wholly or with minor modifications. The expertise and equipment developed at BARC therefore find innumerable applications in general pollution control. HEPA filters today are used in non-nuclear applications and are a very good example of equipment versatility. Clean-room technology developed at BARC was, incidentally, utilised in the design, in-

(*Continued on page 8*)



**HEPA Filter Testing Facility**

**Pd/Al$_2$C$_3$ Catalyst evaluation set-up**



# Some Interesting Investigations at

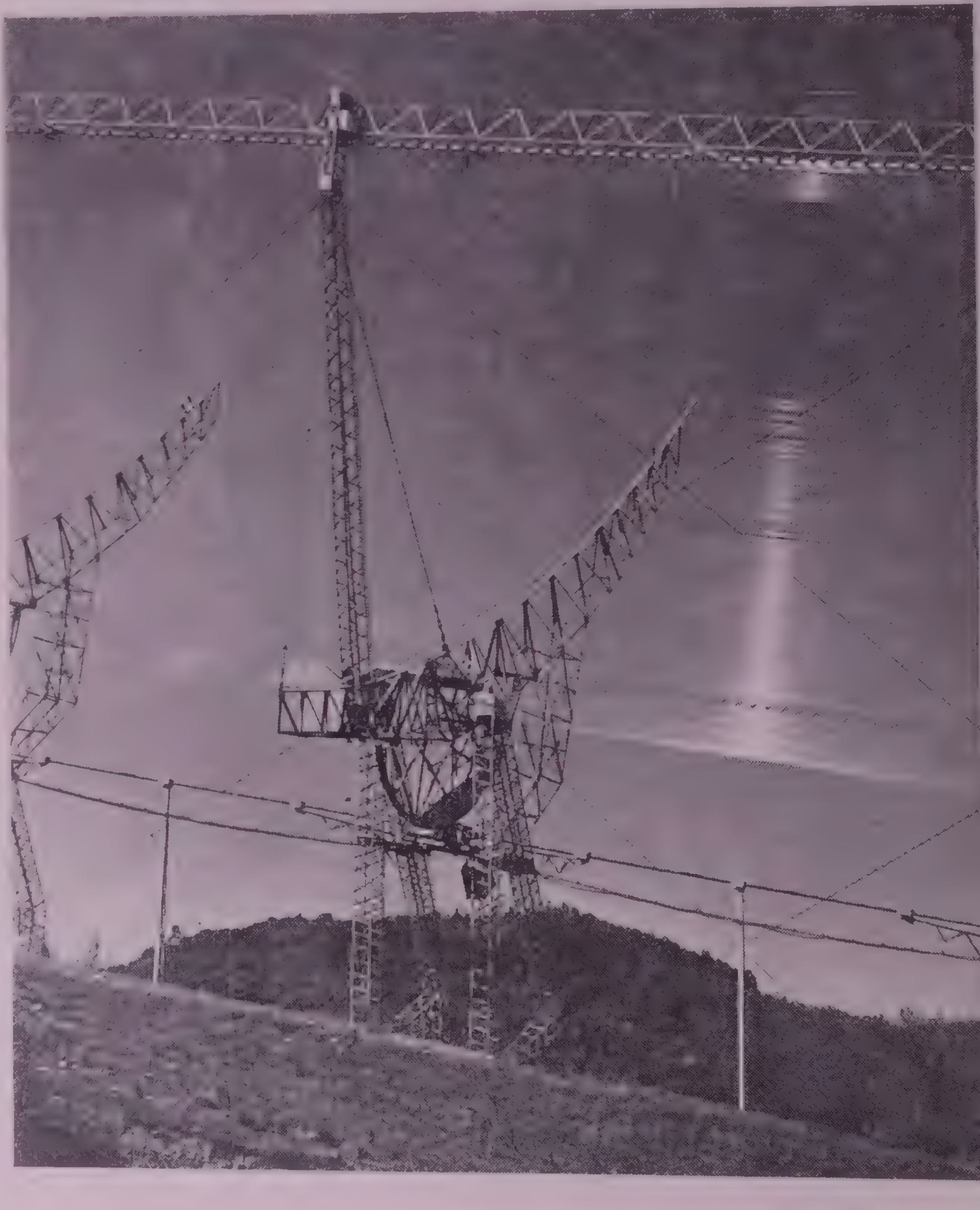
### Radio Galaxies and Cosmology

RADIO astronomy has led to many spectacular discoveries about the universe during the last few decades. A number of these discoveries have provided evidence of the occurrence of truly catastrophic phenomena in many stars and galaxies. In these events are generated high energy particles and magnetic fields following relativistic collapse of massive stellar bodies. The most violent of these phenomena give rise to radio galaxies and quasars, releasing a significant fraction of the entire rest mass energy of the associated galaxies.

One of the strongest sources of radio waves in the sky, *Cygnus A*, was identified by Minkowski in 1952 with a double galaxy located about 1,000 million light years away. It was immediately recognised that it would be possible to detect radio waves from these violent galaxies upto much farther distances in space than possible through the optical window. The radio astronomical observations are therefore of considerable value for studying the structure of our universe.

For explaining the observed expansion of the universe as seen in the optical window, two distinct classes of models have been proposed for the origin of the universe during the last fifty years. According to the 'big bang' cosmology, the universe originated from a primordial fireball, about 10 to 15 billion years ago and is expanding and evolving ever since. In the 'steady state' theory, new matter is created as the universe expands, and the universe has always had the same characteristics as it has today. By counting the number of radio sources against their intensity, Cambridge workers concluded, about 20 years ago, that their observations required higher density of radio galaxies at earlier cosmic epochs than at present, thus supporting the big bang theory. This conclusion was based on an assumption that the weaker radio sources are located, on an average, farther away than the nearby stronger radio sources. However, there has been considerable controversy regarding the nature of the weaker radio sources. Whether

**CYLINDRICAL RADIO TELESCOPE.** Located in the pretty surroundings of Ootacamund, this large radio telescope provides a major facility in radio astronomy. It consists of a 530 m long and 30 m wide reflector and is steerable for 10 hours a day in the east-west and, 32 in the north-south direction. Below. Curved light streak shows reflection of sunlight from the fine stainless steel wire forming the reflecting surface.



# Radio Astronomy Centre, Ooty

PARABOLIC DISH—45-ft. (13.71 m.) diameter, part of the Ooty Interferometer.

they are nearby sources of low intrinsic luminosity or far away sources of high luminosity has been an important question. The distance of a radiogalaxy is measured optically. Radio astronomers do not have any method of measuring distance of a radio galaxy. But as galaxies located very far away are too faint for detection, even by the largest existing optical telescopes, a statistical comparison is made of the observed radio characteristics with theoretical predictions for distinguishing between various models.

Scientists at the Radio Astronomy Centre at Ootacamund have investigated angular size statistics of extragalactic radio sources for the purpose of cosmological investigations. The angular sizes of the weaker radio sources were measured with the Ooty radio telescope by the method of lunar occultation by a team consisting of G. Swarup, M. N. Joshi, N. V. G. Sarma, V. K. Kapahi and Gopal-Krishna. In this method, high angular discrimination is obtained when a radio source is eclipsed by the moon's disc. The giant Ooty radio telescope, one of the largest in the world, was specially conceived with this objective. It has provided angular size data of many hundred weak extragalactic radio sources which are 10 to 20 times weaker than those studied elsewhere. As part of the investigation, Prof. Swarup combined the Ooty data for the weaker sources with those of the strongest sources in the sky that have been studied in UK, USA, Australia and elsewhere. It was seen that the angular sizes of radio sources decreased with decreasing intensity as would be expected if the fainter sources were located farther away in space. At very low intensities, the angular sizes seem to approach a constant value of about 8 to 10 seconds of arc, indicating the effects of curvature of the space. This behaviour is nearly the same even if quasars, whose cosmological nature is a subject of controversy, are excluded from the data. A further detailed theoretical investigation of these results was made by Dr Vijay Kapahi. It is found that the observations can only be understood if the density of radio galaxies is higher and their physical sizes smaller at an earlier cosmic epoch. The results provide a new evidence for the big bang model, and do not support the steady state theory.

### Interplanetary Scintillations

Statistical investigations were also made of some other characteristics of extragalactic radio sources. It is known that radio waves from a compact source show scintillations as they traverse the interplanetary medium, in the same way as stars twinkle due to refractive index variations in the atmosphere. Observations of the interplanetary scintillations of radio sources by A. P. Rao, S. Ananthakrishnan and S. M. Bhandari have provided information about their fine angular structure. It was shown by Swarup and Bhandari that the scintillation visibility of radio sources is correlated with their intensity and overall angular size. These results are also understood if the weaker sources are located farther away in space. The results also indicate that a considerable fraction of the radio emission from extragalactic sources arises from compact components about 1/10th to 1/50th of the overall size.

### Relative Spectra of Extragalactic Radio Sources

A detailed comparison was also made by Gopal-Krishna and Swarup of the relative spectra of compact and

*(Continued on page 8)*

# *Putting Waste Back onto th*

**In a world threatened increasingly by pollution, the disposal of waste is a major headache. Agricultural and animal wastes, however, are often rich in vitamins, proteins, nitrogen and minerals. In India, suffering from chronic food shortages, it is a shame to let such rich resources rot. So Indian scientists are trying to find ways of recycling this waste back on to the food chain.**

YOU would dutifully laugh as if at the latest wisecrack if, at a candle-lit dinner, your pretty hostess were to ask: "Are we ready for the garbage?" But she could be speaking the literal truth. If not right now, it might be possible within the next decade to recycle agricultural waste so that you could be delighted to pick up a variety of canned, mouth-watering ex-garbage at the grocer's and be glad to pay for it.

The candles at this futuristic party would be of tallow recovered from dead animals which foul the countryside. At present, there is no organised way of collecting the carcasses of domestic animals of which more than 26 million die in India every year. Dead cattle number 13.64 million and buffaloes another 4.05 million. The hides are used by village cobblers, particularly since "ahimsak" (non-violent) slippers gained an important place in the Khadi Gramodyog network. But the skinned carcass is thrown away without thought to the loss in terms of money and resources or any concern for the unpleasantness of a rotting carcass which pollutes both air and water.

The rayon sari shimmering on your hostess could be of pulp from jute sticks which now go waste or are, at best, used for hedges, thatch or fuel. The woody part of the plant is nearly 2.5 times the weight of the jute fibre, and is rich in cellulose. The total weight of jute sticks wasted in India is about 2.5 million tonnes.

Even, the aperitif, assuming such things are still in fashion ten years hence, might be from ripe coconut water which is mostly thrown away. Or, it could be from cashewnut apple, the fleshy pulp that bears the prized kernel. It is fibrous and astringent in taste when eaten fresh from the tree, but rich in vitamin C, fruit sugar, calcium, phosphorus and iron.

After processing, the cashew apple can be turned into juice or syrup, or fermented into liquor. It can also be turned into candy, canned fruit, chutney, pickle or curried as a vegetable. The Central Food Technological Research Institute (CFTRI), Mysore, has worked out details of the possible use. If this technology can be transferred to cashewnut growing areas which are among India's poorest regions, people could benefit from an inexpensive and readily available addition to their meagre diet.

When your hostess finally dishes out the "garbage", you might find that the staple roti (unleavened bread) was made from the starch-rich mango kernel. The CFTRI has found that this can be done. It has also been able to extract oil which forms about 12 per cent of the weight of the mango stone. Pectin, used in jellies and syrup, can be made from mango peel, as recent experiments have shown. All this should be of great value to this country where roughly 420,000,000 people live below the poverty line and wage a constant battle to grapple with starvation.

Waste from mango products adds upto 8,500 tonnes a year. In 1970 the waste from fruit and vegetable processing centres amounted to 25,000 tonnes. The total wastage all over the country should be higher as India grows 15 m-20 m tonnes of fruit and vegetables, of which hardly 0.4 per cent goes to the processing industry.

Atta (whole wheat flour) could be mixed with high-protein cotton seed flour if the on-going experiments at the CFTRI prove useful. This has already been done successfully at a research centre in Guatemala which has evolved a nutritious mixture of cotton seed and maize flour. In any case after oil is extracted from it, the cotton seed cake could be widely used as excellent cattle-feed.

Unless she wants to make a cult of using waste, your hostess need not go in for pea shell pulao, fried onion trimmings, potato peel soup or sweet and sour stalks of cabbage, cauliflower or lady's finger (okra). But her vegetables could be grown on soil enriched with compost made from a variety of waste products from the kitchen, the farm and residues from the tea, coffee or sugar milling industries. Fish could be fed on blood meal made from slaughter-house wastes. "Rubbish" from abattoirs, such as glands, trimmings and intestines, could be turned into sausages. And everything could be cooked in oil from cotton seed, tobacco seed or rice bran. This last variety of oil has a tremendous future in India.

Rice is one of India's major crops. At present, we produce about 65 m tonnes of paddy in a year. This yields 40 m tonnes of rice, about 10 m tonnes of husk and two million tonnes of bran. With better milling, the bran could go up by another 400,000 tonnes. Rice bran, the brown coating on the grain, can yield 15-20 per cent good oil. The total oil obtained could be around 400,000 tonnes, valued at Rs 12 million. Rice bran oil is very popular in Burma, Thailand and other countries of South-East Asia.

Our problem is that most of the bran, mixed with husk, is used as animal feed or burnt as inferior fuel. Also, unless the bran is stabilised the oil would be spoilt by the free fatty acid present in it. Parboiling helps, but people in northern India turn away from this type of rice. The CFTRI and Jadavpur University have therefore, evolved a couple of new methods of stabilising the bran. These are yet to be tried out commercially

# ood Chain

Whatever little rice bran oil is produced in India today is used up by the soap industry.

Thanks to the Khadi Gramodyog and a number of Gandhian centres, the production of methane from cowdung and other waste products has received a big boost in recent years. So, if your hostess happens to live on a farm, she would have cooked everything on a gobar (cowdung) gas stove.

India claims the world's largest cattle population, producing a total of about 1,335 m tonnes of wet dung which all goes waste. Using dried-cowdung cakes as fuel means not only burning up a valuable resource, but also adding smoke and carbon dioxide to fresh air, turning it foul. At present only 33 per cent of the cattle-dung in the country is turned into manure. But, even if a farmer owned five head of cattle, he could be assured of a supply of 60-100 cubic feet of methane in a day. This is enough cooking gas for a family of five. Over and above this, there may be spare gas to light a lamp or two.

The only drawback seems to be that the cost of setting up a plant—about Rs 3,000 is too high by village standards. Even when the money is there, men are reluctant to invest it in an apparatus that will mainly benefit women, the traditional underdogs of society. Indian technicians, however, are trying to come up with cheaper models. Already, the adaptation of a Chinese model used in some parts of India has cut down the cost by a third.

Vegetable waste added to the dung may make for more and better gas. If cultural taboos can be overcome, human excreta can also be used. In that case, not only will a major, country-wide sanitation problem be solved, but homes possessing fewer head of cattle will also be able to set up their own methane plants.

The slurry from the gobar gas plant is excellent manure. It can also be used to grow algae, the green slime that forms in untended tanks and water cisterns. Algae are a rich form of single-cell protein which can be used as soil-fertiliser or cattle-feed. Our scientists are experimenting on how to eliminate the dark green colour of the dry powder and turn it into an acceptable additive to human diet.

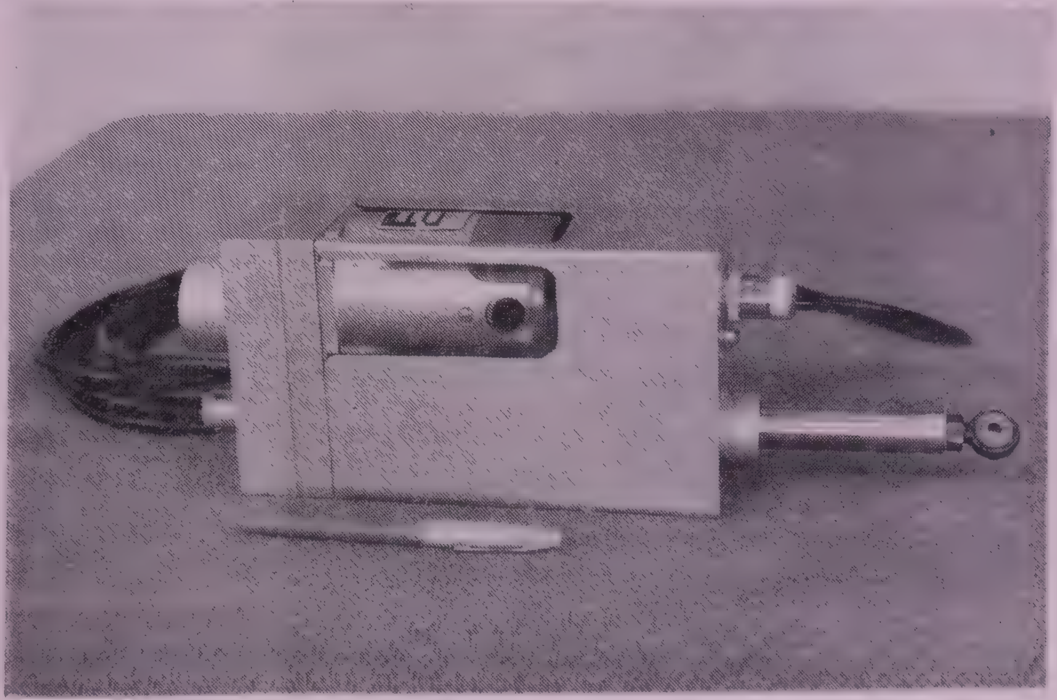
(*Continued on page 8*)

## Dr. Ramanna Moves to Defence Ministry

Dr. Raja Ramanna, who handed over charge as Director, Bhabha Atomic Research Centre on June 30, 1978 has taken over as Secretary to the Govt. of India, Ministry of Defence, for Defence Research. He is concurrently the Scientific Adviser to the Defence Minister and Director General, Defence Research and Development Organisation.

Dr. Ramanna is President of the Indian National Science Academy and a Member of the National Committee on Science and Technology, Vice-President of the Indian Academy of Sciences and a Fellow of the National Academy of Sciences, and the India Society of Engineers.

## *A Compact, Light Actuator from BARC*



**This is an electro-mechanical linear actuator developed by the Central Workshops of the Bhabha Atomic Research Centre, Trombay for use in a "hot cell" equipment. The actuator is compact, of light weight and has good load capacity—features that make it a versatile tool for use in many other applications where remote-controlled or preset actuation of mechanical devices is required. The actuator has a push-pull capacity of 200 kg. and a stroke of 130 mm (adjustable). It measures approx. 70 mm x 125 mm x 225 mm, and operates on 28 Volts AC/DC. Its utility can be further increased by adding suitable motion/force converters, depending on specific needs. By a simple conversion, the unit can also function as a compact geared motor.**

## Air Cleaning

*(Continued from page 3)*

stallation and testing of the clean-air facility for providing and maintaining a dust free atmosphere for the assembly of India's first satellite, Aryabhata.

Many concepts and systems for achieving ultra-clean environments to carry out special processes have been developed at BARC to meet the specific needs of nuclear programmes. Based on this experience and the feed-back data from such systems already in operation, the BARC is in a position to provide design and consultancy services to meet the air cleaning requirements connected with many special industrial and research programmes outside the nuclear and space research fields. ●

## *Recycling Waste*

*(Continued from page 7)*

National laboratories, farm universities and research centres are trying to find new uses for waste products. Certain technologies have already been perfected and private entrepreneurs invited to take up the challenge under a system of licensing. But, very often, even when the know-how is developed, there are no takers.

While going commercial, however, products which villagers and tribal people use as food should not go completely out of the hands of the locals. We have seen the conversion process of cooking oils—like those from sal seeds, mahua seeds and so on—being suddenly declared as "non-edible" and handed over to the soap and other industries. If there are toxic elements in these traditional cooking oils, efforts should be made to find easy, village-level processes to render them harmless so that those who have been using them for generations are not deprived of their inexpensive cooking media. The village housewife should not be forbidden to cook with mahua oil, for instance, simply because some city-bred snob finds its colour or odour distasteful.

If the priorities are thus set right, and the goals for helping the masses clearly defined, we could, in time lick two problems: of waste disposal and of hunger with one massive effort. Recycling of waste, as an important component of a wider, overall campaign, may yet ensure decent, regular meals for many of cur poorest who subsist almost on garbage dumps (*PIB*).

## Ooty Will Have A Synthesis Radio Telescope

A SYNTHESIS radiotelescope is being built at Ootacamund by the Radio Astronomy Centre of the Tata Institute of Fundamental Research, Bombay. The Centre already has a 530 metre long, 30 metre diametre cylindrical radiotelescope at Ooty, built in 1970 by the Radioastronomy Group of TIFR. The new telescope will provide Indian scientists a front-line capability in radioastronomy.

A synthesis radiotelescope consists of several antennas spaced widely apart, with outputs suitably combined to give interference pattern of fringes. With the rotation of earth, their spacing gets foreshortened due to projection effects with respect to the incoming radio waves from a distant source in the sky. By computer processing of the data acquired over the day, it becomes possible to synthesize the full aperture covering all antennas.

The Synthesis Radio Telescope will consist of 7 antennas. It will provide a sharp picture of the radio sky with the same clarity as a parabolic dish of 4 km diameter. By 1980 another 6 to 8 antennas are proposed to be added upto a distance of 9 or 12 kms, making it the largest radio telescope in the world operating at a metre wavelength. The telescope will be fully operational by the end of 1978. By 1980-81, it is proposed to expand the instrument to achieve 4 times better resolution and to have a capability of making very fast survey of the radio sky, faster than anywhere else in the world.

Scientific observations have already been started with a part of the instrument already built. The large collecting area and steerability of the cylindrical radiotelescope is being advantageously used by the new instrument.

The extraordinary sensitivity o this telescope and its special capability for making very fast surveys o the sky may lead to remarkable discoveries; may be even of signals from an extra-terrestrial civilization. ●

## *Investigations at Ooty*

*(Continued from page 5)*

extended components of extragalactic radio sources based upon their high resolution observations made at Ooty and Cambridge. It was shown that acceleration of relativistic particles occurs over a wide region.

**Pulsars**

The enigmatic pulsars discovered in 1967 are of great astrophysical interest, as they involve extremely dense matter and strong magnetic fields explaining their properties. Three pulsars were discovered in 1971 at this observatory. Recently an observational programme aimed at discovering very weak pulsars has been started. This has already led to the discovery of two new pulsars and many more suspects are to be confirmed shortly. Pulsars take birth in violent explosions of stars and are expected to be high velocity objects. Their signals exhibit scintillations due to the interstellar medium. A collaborative observation by scientists at Ooty and those in Australia, using a technique based on interstellar scintillation has led to the conclusion that not all pulsars are high velocity objects, and also that the stellar medium does not have stable characteristics. Further studies at this observatory have revealed peculiar behaviour by pulsar signals which imitate scintillations caused by the interstellar medium. ●

Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India,
Chhatrapati Shivaji Maharaj Marg, Bombay 400 039, and printed by him at G. Claridge & Co. Ltd., Bombay 400 001.

**Registered No. R. N. 9002/62**

NUCLEAR INDIA

VOL. 16 No. 12 PUBLISHED BY THE DEPARTMENT OF ATOMIC ENERGY AUGUST 1978

# *Comparative Biological Hazards of Chemical Pollutants and Radiation*

**By Dr. Ramendra Nath Mukherjee**

Radiation Biology and Health-Related
Environmental Research Section, IAEA

IN a discussion on the hazardous biological effects of ionizing radiation and chemicals, an essential prerequisite is the enunciation of the actual context, and the specific criteria involved so that the problems can be assessed in their real perspectives. Ionizing radiation, and many chemicals are known to produce hazardous health effects on man and other organisms. Both categories of agents further exhibit dose-response relationships in the production of their biological effects. This leads to the prediction that by minimizing the extent of exposure as far as achieveable, their harmful effects could be greatly reduced, or even altogether avoided.

In applying radiation and chemicals for some beneficial purposes, development of a good protection programme should be an essential requirement. The philosophy underlying the programme should be that all unnecessary exposures of people are avoided and that any necessary exposure, whether of workers or of members of the general public, is minimized. An additional requirement could be that even such necessary exposures should not exceed certain stated limits. These principles are based on the consideration that even the smallest exposures may involve some risk, that any risk should be justifiable by the circumstances necessitating it, and that the risk should always be limited to an appropriately low level. This concept is vital and is the determining factor behind any efforts for controlling the emission of such hazardous agents.

The peaceful applications of radiation are well supported by such health protection programmes. It is heartening to recall that even when the first nuclear reactor went critical some 35 years ago, there was already background data based upon several decades of close critical study of the types of harmful effects that might be caused by radiation, and information on the frequency of their induction by a given radiation exposure. The International Commission on Radiological Protection (ICRP), which had already been set up at that time, had formulated standards of exposure dose limits and guidelines.

### Toxic Chemical Substances

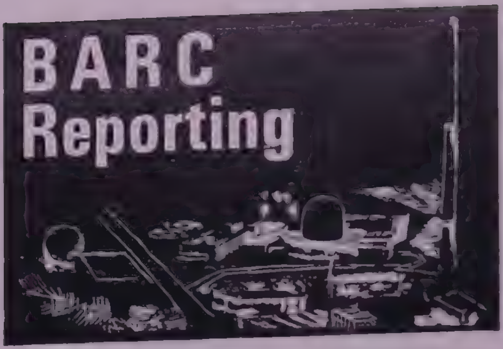
In sharp contrast to the peaceful uses of nuclear energy, which have been pursued in an atmosphere of caution since inception, no early effort was made towards understanding critically the risks arising out of toxic chemical substances released to the atmosphere from fossil-fuelled power stations, and chemical and petrochemical industries. It is only during the last decade that there has been a growing awareness of such pollution and attempts made to safeguard man and his environment against the deleterious effect of environmental chemical pollutants.

The United Nations' sponsored conference in Stockholm in 1972 on "Man and His Environment", and the subsequent establishment of a specialized agency of the United Nations (United Nations Environmental Programme or UNEP) testify to this growing concern for the preservation of a clean, viable environment. Concurrently, several national, regional and inter-regional scientific societies have set out to identify, monitor and help prevent possible further exposure of man to noxious and toxic substances.

The magnitude of the problem of man's exposure to chemical pollu-

(*Continued on page* 4)

*'Environmental chemical pollution problems are more than national in scope. They qualify for consideration as a "global problem", demanding international action.'*



## BIOLOGY AND AGRICULTURE DIVISION

### Capacity of Roots to Absorb, Transport Micronutrients

THE inherent capacity of roots to absorb and transport micronutrients—iron and manganese—was examined in bean plants grown for different periods, from 11 days to 42 days. The plants were allowed to absorb $^{59}$Fe or $^{54}$Mn labelled 0.1mM of $FeSO_4$ or $MnSO_4$ for 24 hours and the amount of $^{59}$Fe or $^{54}$Mn in different parts were assayed. It was found that the capacity of the roots to absorb Fe and Mn decreased with the age of the plants. Furthermore, the retention of Fe and Mn in the stem continued to increase from the 11th to 31st day, while it decreased with age, in the case of primary leaves. It is significant that the newly growing leaves *viz*. the first, second or the third trifoliates retained larger amounts of Fe or Mn than that in the primary leaves. The results show that when Fe and Mn are available in the root medium, they would be readily translocated to new growth. However, the capacity of the roots to absorb the micronutrients diminishes with the advance in growth, even under conditions of sufficiency of the elements in the root medium. When the transport of $^{59}$Fe and $^{54}$Mn to other plant parts is compared to the amount absorbed by the roots, Mn is found to be transported more efficiently than Fe. These studies indicate that iron and manganese, when applied in early stages of growth, are effectively absorbed and utilised.

* * *

### Binding Properties of Lectins

Lectins, the proteins characteristic of legume root walls, are considered to be involved in recognising and binding the nitrogen-fixing rhizobia strains capable of infecting their specific legume hosts. This has now been demonstrated by the use of purified and radioactively labelled lectin.

Peanut lectin (peanut agglutinin, PNA) precipitated by using ammonium sulphate and separated by ion exchange chromatography on DEAE cellulose was further purified by filtration on Sephadex-150 gels. The highly purified PNA was labelled with the fluorescent dye fluorescein isothiocyanate (FITC). In order to achieve more definitive results, PNA was further labelled with $^{125}$iodine ($^{125}$I) by a chloramine-T oxidation procedure with the help of the Radiopharmaceuticals Section of Isotope Group. Labelled PNA bound to rhizobia which nodulate groundnut plants, but did not bind to rhizobia which nodulate soyabean and alfalfa, or to non-nitrogen fixing bacteria. The results clearly indicate that legume root wall lectin recognises and binds specific rhizobia capable of nodulating the host plant while rejecting other rhizobia and bacteria present in the soil.

### Symposium on Power Plant Safety and Reliability

| | | |
|---|---|---|
| *Venue* | .. | Bhabha Atomic Research Centre, Trombay, Bombay-400 085 |
| *Date* | .. | January 17-19, 1979 |
| *Deadlines* | .. | Extended Abstracts: Oct. 1, 1978 |
| | | Papers: December 15, 1978 |

Topics proposed to be covered:

(i) Codes of practice for design and operation and maintenance—Regulatory and Licensing Procedures including Documentation such as Design Analysis and Safety Reports, (ii) Containment and Siting for Power Plants, (iii) Analysis of Postulated Accidents, Hazards Evaluation including Computer Modelling, (iv) Experimental Studies and Safety Research, (v) Design and Operating Experience of Safety and Protection Systems and Engineered Safety Features, (vi) Plant Reliability—Data Collection and Techniques of Reliability Assessment—Reliability Studies in System Design, (vii) Role of Quality Assurance in Safe and Reliable Performance of Systems and Components, (viii) Environmental Impact of Power Stations.

*All communications may be addressed to :*

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Colaba, Bombay-400 005.

## RADIOLOGICAL PROTECTION

ADVICE on radiation safety measures and planning of radiation installations was provided during July 1978 to 311 institutions in the country. An isotope laboratory and two industrial radiography installations were approved for construction. Eight inspection visits were also conducted during this period. Permission to procure and handle radioisotopes was accorded to 58 medicinal, 62 industrial and 19 research and agricultural institutions. Radiological Protection Survey was conducted in 20 medical, 4 industrial and 2 research institutions during this period. One each of clinical dosimeter, contamination monitor and a gamma radiography survey meter were supplied to outside institutions on request.

A total of 19,060 radiation workers from 1827 institutions all over the country were monitored for personnel X, beta and gamma exposures.

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## Computer Industry

*(Continued from page 3 )*

and Production Planning. The ultimate success of a computer system lies not only in the reliability of its hardware or its elaborate software, but also in its intelligent use. The usage has to be appropriate in the Indian context.

Of the total number of computers in India today, 154 are IBM machines and 100 are ECIL machines. 21 Data Processing Systems have been supplied and commissioned by ECIL, of which 18 are the TDC-32 variety. Whereas, in the initial stages, ECIL systems did have some teething troubles, reference to the availability of the TDC-312 systems today indicates that the average monthly availability is better than 95 per cent. This is sufficient proof that commercial data processing systems of ECIL have come of age. ECIL will commence marketing its TDC-316 systems for data processing purposes from April 1979 and its Midi Computer Systems based on TDC-332 would be available a year later.

I would like to see a dispassionate evaluation of the indigenous computer industry. After all the indigenous manufacturer is trying hard to excel in his product just as any foreign manufacturer does. ●

# ‘The Computer Is The Control Element in all Commercial, Engineering Activities’*

OF all the fruits of modern technology, the computer perhaps has come to attain the most pervasive influence in society. In the three decades that have passed since it made its first appearance, essentially as a device to perform fast calculations, the computer has grown to become the central control element in almost all commercial and engineering activities. In a way, the advent of the computer has had as great an impact on society as the industrial revolution of the nineteenth century. It is hard to visualise an area which remains, or will remain in the foreseeable future, unaffected by the sweep of the computer’s influence.

The first computer installed in India was perhaps the one in the Indian Statistical Institute at Calcutta, in the 1950s. Though more than 400 computer systems are now operational in different parts of the country in a variety of applications, this is a small figure compared to that in countries like Japan, Germany, U.K. and the U.S.A. Perhaps this state of affairs is in tune with the normal problems that tend to make technology growth comparatively slower in the developing countries. But the usage of computers has to be widened in the country because of the computer’s impressive power to accelerate development. **The narrow view that computers displace men from jobs and, as such, do not fit into a situation of widespread and heavy unemployment is totally erroneous and must be given up in the national interest.**

We have already seen that computers are very sophisticated electronic systems with unique capabilities essential to the efficient performance of wide-ranging industrial activities, and play vital roles in defence, communications and the general industry. Their capacity for information processing at very high speeds and their ability to work as an integrated part of a controlling system make it possible to use them in automatic control of industrial processes where direct manual control is impossible, not only because of environmental risks to human beings but also because of otherwise highly inefficient, wasteful and unreliable plant operations and the severe economic losses resulting therefrom. Used in operations such as production planning, shop loading, inventory control, etc., computers have an important role in maximising production and efficient utilisation of a developing country’s precious resources. Their high speed information processing capability, their ease of handling a large number of variables normally beyond the endurance of manual computation and their reliability in data output are powerful tools for economic planning and speedy decision-making on which national development critically depends.

A characteristic of the computer manufacturing industry is its catalytic role in the economy of any country. This is evident from what has happened in developed countries, like the U.S., Germany and Japan. **The computer industry sustains the growth of many supporting industries like semi-conductors, integrated circuits, core and other memories, peripherals and several ancillary industries in the small scale sector.**

It was clear to those who observed the initial developments that unless a foundation was laid for the indigenous design and manufacture of computers, the Indian market would be at the mercy of foreign concerns waiting to exploit the opportunities that would fetch them exorbitant profits through sale of discarded machines which they could otherwise only scrap. It is this early realisation that helped this country launch its efforts for an indigenous computer industry and be able to attempt to withstand aggressive market invasion by the foreign computer companies.

Taken with the prevailing opinion that high technology products like computers must be imported for fear that their quality would be beyond Indian manufacturers, it was not surprising that ECIL had a tough battle on its hands. However, there were many arguments, justifying the need for self-reliance in computer design and manufacture. Areas such as Defence, Nuclear Technology and so on can be served only by such a national effort in view of the obvious reluctance on the part of the advanced countries to share their technology with the growing nations. Even countries such as the U.K., France, Germany and other nations of Europe, with all their technological progress, have felt the need to have an independent computer industry of their own. Where necessary, they pooled their resources through mergers and associations of their several companies and this had the unstinted support of their governments. Even today, such government-funded backing continues for large systems.

The vital significance of the computer industry, especially in the context of Defence, and the need to base this industry on self-reliance is under-scored by the vast flow of U.S. Government funds to IBM through defence contracts. Viewed against this background, the need for India to be self-reliant in computer technology was, and continues to be evident. Earlier, ECIL concentrated its efforts in optimising the operations of capital plants using process control computers and real-time systems. Over the last few years, ECIL has installed about 100 systems, of which 56 are scientific systems and 22 are real time systems. ECIL has undertaken several custom-tailored assignments such as Automatic Message Switching Systems for the Air Force, Ammonia Plant Control System for the Gujarat State Fertilizer Company, and Crime Detection Systems for the Police. The data processing applications, which it is promoting, are primarily to improve management decision-making in various areas such as Inventory control, Linear Programming

*(Continued on page 2)*

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*Address by Dr. H. N. Sethna, Chairman, Atomic Energy Commission, on the occasion of the inauguration of TDC-312 Computer System on August 2, at a private industrial unit at Bombay.

# 'Chemical Pol
# Water Knows

*(Continued from page 1)*

tants in the environment may be appreciated against the fact that about 500,000 to 600,000 chemicals (the number growing at an annual rate of about 500) are produced and utilized in the United States alone. Similar figures may be shown for the other industrialized regions.

In this article further discussions on the comparative biological hazards of chemical pollutants and radiation will be carried out under the following headings: (i) their sources, including relative abundance in the environment; (ii) their mechanisms of action for biological effects; (iii) their relative impact on man's health and environment; and (iv) the status of the current and proposed regulatory measures, and steps to safeguard human health against these pollutants.

## Environmental Chemical Pollutants of Health Significance

THE unfavourable alteration in natural environment through man's activities dates back to the time when man first learnt to produce fire. From then on, combustion products continued to gain entry into the atmosphere and pollute the environment. A significant landmark in the history of environmental pollution coincides with the industrial revolution a couple of centuries ago. Concomitant with the increasing availability of coal and fossil-fuel energy sources, and their utilization in the multifarious industrial processes to meet the growing demands of urbanization and rising living standards, the rate of pollution of the environment has been dramatically aggravated.

Table 1 shows the growth in the production of some representative chemicals in the USA. One aspect of this exuberance is illustrated by the fact that there are now more than 55,000 pesticide formulations registered with the Department of Agriculture. The Food and Drug Administration (FDA), which by law in the USA is required to certify the safety of pesticides and food additives, receives on an average roughly one new petition every working day in the year. A similar situation is found in other industrialized countries, with some variations in the details and quantities. These chemical and petrochemical industries release as effluents large quantities of toxic and noxious substances into the atmosphere. Human populations located far and wide, not to mention the occupational populations in those industries, thus receive chronic exposures and consequent health hazards.

**Table 1: Production of synthetic organic chemicals (millions of pounds/year)**

| | 1938 | 1958 | 1966 | 1980 (estimated) |
|---|---|---|---|---|
| Plastics .. .. .. .. | 130 | 4500 | 13585 | 75000 |
| Synthetic rubber .. .. .. | 5 | 2200 | 3929 | 10000 |
| Surface active agents .. .. .. | — | 1355 | 3321 | 8500 |
| Insecticides and agricultural chemicals (excluding fertilizers) .. | 8 | 540 | 1013 | 6350 |

Source: USA Tariff Commission Report.

**Table 2: Forecasts of installed electric & nuclear capacity (in thousands of MW)**

| | 1976 | 1977 | 1980 | 1985 | 1990 | 2000 |
|---|---|---|---|---|---|---|
| Total electric .. .. | 1700 | 1800 | 2200 | 2800–3000 | 3600–3900 | 5900–6600 |
| Total nuclear .. .. | 85 | 95 | 170 | 300–400 | 500–700 | 1300–2000 |
| Percentage nuclear .. .. .. | 5 | 5.3 | 8 | 11–13 | 14–18 | 22–30 |

Source: IAEA Annual Report 1977.

Table 2 illustrates trends in power sources estimated till the end of the current century. Two of these energy sources, namely fossil fuel and nuclear, are believed to pose environmental health problems. Combustion of fossil fuels poses severe air pollution problems. Nuclear power sources, although with a potential for radiation pollution, have succeeded in maintaining a clean, safe record for more than three decades—thanks to the continuous improvements in technologies and strict surveillance and monitoring during operations.

Coal, oil and other fossil-fuel energy sources pollute the environment with sulphur oxides and other sulphur-containing products. Carbonaceous particulates, excessive quantities of fly ash, carbon dioxide, some heavy metals such as mercury are among the pollutants which enter the atmosphere from the operation of conventional energy installations. Manufacturing factories for chemicals, petrochemicals, rubber, plastics, pesticides, and dyes for textiles continue to overburden man's environment with a plethora of noxious chemical pollutants.

To these are added pollutants such as carbon monoxide, carcinogenic hydrocarbons and metallic lead from automobile exhausts. At present more than 3,500 food additives are in use throughout the world. The use of polyphenols for the preservation of foodstuffs may be another potential health hazard. Chlorinated hydrocarbon insecticides such as DDT, dieldrin, endrin, persist in the soil and may be transmitted into man's food chain.

This inventory of hazardous chemicals in man's environment may

# ion of Air and o Boundaries'

be regarded as representing only a fraction of the total to which current human populations are chronically exposed. Generally, there has been little world-wide public concern for health hazards from these chemical pollutants until very recently. In many instances there has been concern shown only after a catastrophe, such as the mercury poisoning in Minamata, Japan, and the "*itai itai*" disease caused by cadmium pollution.

Furthermore, chemical pollution of air and water respects no boundaries. The art and historical treasures of the ancient civilizations of Rome and Athens are damaged by the acids and gases of automobile exhausts and industrial smog. Snow falling on Norwegian forests comes down gray with soot and mineral wastes from industrialized areas far from the nation's frontiers. Residues of insecticides such as DDT, chemical fertilizers, vinyl chloride from plastic factories, heavy metals such as mercury, lead, cadmium and vanadium, and spilled crude oils and petroleum move in ever growing volumes through the hemispheres with wind and ocean currents. Many environmental chemical pollution problems are thus more than national in scope and qualify as a "global problem", to be solved by appropriate international action.

### Radiation and the Environment

DISCUSSION of ionizing radiation in the environment must start with the natural background sources. Mankind has since time immemorial been bathed in low levels of gamma radiation and cosmic rays, and exposed to radioactive nuclides in the earth's crust. In addition, radioactive substances leached or absorbed from soil and ingested with food or water have irradiated man from within. The average dose of ionizing radiation from these natural sources, also called "background", on a world-wide basis is about 100 millirems per year, the usual variation being less than a factor of two.

At the current stage of development of nuclear technology, two main sources for exposure of general population to man-made radiation may be recognized: (a) sources for medical uses of radiation and (b) radioactive wastes from nuclear installations. To this a third category could be added —fall-out from nuclear tests (which nowadays have progressively lessened in significance).

The largest increment to the natural background level of radiation (100 millirem per year) is the 25 to 50 millirem from diagnostic uses of X-rays. Recent developments in technology, including the use of high-speed films and limiting exposed areas through collimation, give further promise of reduction of this exposure dose by as much as 75 per cent. Industrial sources of ionizing radiation, including the rapid growth of nuclear power programmes, have contributed only a negligible addition to the general population exposure dose. The safety accomplishments of nuclear technology are primarily attributable to the high standards in the technologies involved as well as prudent implementation of the strict management and surveillance practices.

Well over 99.9 per cent of the radioactivity generated in the power reactors is retained within the casings of the fuel elements until they are subjected to reprocessing. Because of this and the fact that one fuel reprocessing plant may serve a large number of power reactors, no major impact of this radioactivity on the environment is anticipated. Systematic study on the characteristics of effluent discharged to the environment from an operating boiling water reactor indicated $^{3}H$, $^{58}Co$, $^{89}Sr$, $^{90}Sr$, $^{131}I$ and $^{137}Cs$ in the liquid wastes would account for an average contribution of the total activity of $0.189 \times 10^{-7} \mu Ci/ml$ over a one year period. In addition the gaseous effluent consists of noble gas fission products $^{85}Kr$ and $^{133}Xe$.

### Biological Actions of Chemical Pollutants and Radiation

SOON after the discovery of X-rays and radioactivity, research into the biological effects of ionizing radiation demonstrated its lethal effects on individual cells as well as on whole organisms. About this time, by the end of the first quarter of the current century, H. J. Müller discovered the mutagenic actions of ionizing radiation. This discovery, while providing a valuable tool for genetic research, simultaneously raised the spectre of an entirely new kind of health hazard, that of injury to future generations yet to be born.

Studies on biological systems (using radiation doses much higher than those to be potentially encountered by the general population in the environmental context) have shown that genetic effects of ionizing radiation increase in direct proportion to the dose received. In addition, it is assumed there is no threshold dose below which genetic effects are not expected to be produced. This conservative approach, based on the concept of "no threshold for genetic injury" has been used by the various international and national recommending bodies, such as ICRP and the U.S. Federal Radiation Council, in the establishment of doses permitted for the general population and for the radiation workers.

About ten to fifteen years after the initiation of research on the biological effects of ionizing radiation, studies on the genetic actions of chemical agents on biological systems started through the pioneering efforts of C. Auerbach in the U.K. The rapid advances in the cell biology and genetic research with the enunciation of DNA as the chemical and molecular basis of heredity and cell functions furthered the understanding of the basic mechanisms of the biological effects of radiation and chemicals. Leaving aside the differences in the detailed mechanisms of chemical actions on DNA, the end biological effects produced by most of the chemi-

(*Continued on page* 6)

# *Nuclear Experience Is Helpful in Checking Environmental Pollution*

*(Continued from page 5)*

cal agents closely resembled those of ionizing radiations. In other words, many chemical effects "mimicked" radiation effects and were thus designated as "radiomimetic agents".

### Comparative Environmental Impact of Chemicals and Radiation Pollutants

ALTHOUGH an increasing number of chemical pollutants are suspected of giving rise to cancers of different types, still there is a lack of systematic human data which can be used for numerical risk analysis as are available in the case of ionizing radiations. Such carcinogens include inorganic substances like asbestos, arsenic, chromium, nickel and organic substances such as benzo(a)pyrene, benzidine, vinyl chloride and coal tar among others.

Benzo(a)pyrene is produced in substantial quantities in the burning of coal and is also present in automobile exhaust fumes. Benzo(a)pyrene concentrations in different big cities of the world lie in the range of 1 to 4 $ng/m^3$ (excluding the areas with high industrial concentrations). The radiation dose equivalent for 1 $ng/m^3$ benzo(a)pyrene in the air has been calculated as 240 millirem/year. From this it can be inferred that the current risk of benzo(a)pyrene inhalation alone is nearly 100 times the risk of projected radiation dose of a large nuclear power programme.

Some of our recent knowledge of the health hazards from low-level chronic exposures to suspected specific chemical pollutants are based on epidemiological studies.. A classic example is provided by surveys of plastic industry workers exposed to vinyl chloride effluents. Significant increase in the incidence of specific liver cancer, angiosarcoma, in the exposed workers has been reported from different countries, and these studies have established the carcinogenic properties of vinyl chloride. Similar epidemiological and experimental studies on certain therapeutic agents, such as halothane used for anaesthesia, hycanthone for control of schistomiasis, and diethylstilbestrol used for treatment of cervical cancer, have revealed carcinogenic and mutagenic side effects in the treated patients and in some cases even in their progeny. Experimental screening of a wide range of chemical agents from our daily utility list and from our immediate environment have shown that some have potent mutagenic and carcinogenic properties.

Table 3 shows the comparative estimates of health effects associated with the total fuel cycle, including the currently available alternative energy sources as computed by the Biomedical and Environmental Assessment Division (BEAD) at Brookhaven from 1975 U.S. data. The implications of these data on the comparative health effects of radiation from nuclear power sources and fossil fuel sources are self-evident. Air pollution from fossil fuels is by far the largest contributor to the deaths recorded.

**Table 3 : Comparative health effects associated with alternative energy sources***

(data standardized for total fuel cycle to produce 1010 KWh electric power)

| Fuel | Estimated deaths | Estimated disabilities |
|---|---|---|
| Coal .. .. | 10–200 | 300–500 |
| Oil .. .. | 3–150 | 150–300 |
| Gas .. .. | 0.2 | 20 |
| Nuclear power .. | 1–3 | 8–30 |

*Estimate based on 1975 U.S. data.

Source: L.D. Hamilton and A.S. Manne.

### Steps for Control of Environmental Pollutants

RESEARCH on the identification of suspected chemical pollutants and the evaluation of their carcinogenic and mutagenic effects at the lowest dose levels of exposure have been instituted by the various regional centres of the world. These activities have taken into account the hazardous indigenous chemicals of significance which are locally used in industry, foods, agriculture and public health care. In the course of this investigation, if a chemical agent is found to have mutagenic and/or carcinogenic effect on the biological test system(s), the agent is recommended for withdrawal from the market and if available, a substitute non-carcinogenic alternative form is introduced instead. Such activities have been sponsored by the national and regional scientific societies for the investigation of environmental carcinogens and mutagens and co-ordinated by the International Association for Environmental Mutagen Societies (IAEMS), and the U.S. National Institute for Environmental Health Sciences.

The international scientific experts in the field of environmental studies have further recommended the establishment of an "International Commission on Protection against Environmental Mutagens and Carcinogens"—somewhat along the pattern of the International Commission on Radiological Protection (ICRP). It is further recognized that the problems relating to the protection of man against chemical pollutants could have much benefit from the extensive relevant experiences of the nuclear fields and from successful protection record against radiation in particular. Attempts are now being made to "equate" the hazardous biological effects of specific chemical pollutants in terms of the "rad-equivalent chemical" units or REC units (*i.e* equivalent biological effects, in terms of say, mutagenicity or carcinogenicity produced by certain dose-level of a chemical agent and the ionizing radiation expressed in rad units). Implicit in such an attempt is the objective of expressing the overall "health risk commitment" from the combined exposures to chemical pollutants and radiation in the environment. Needless to say such attempts are in their preliminary stages and are still fraught with many technical uncertainties.

In keeping with its objectives,

# *Remarkable Safety Record of World Nuclear Power Installations*

the IAEA promotes the practical applications of nuclear techniques to help solve the environmental pollution control problems. For example, through research support and coordination, the techniques of neutron activation analysis have been elaborated into suitable methods applicable for the epidemiological survey of heavy metal contamination in human hair samples. Activation analysis has also been extended for the detection of pesticide residues, and for the correlation of metallic pollution with the incidence of cardiovascular diseases. Genetic (biological) control of insect pests of agricultural crops ("sterile male technique" using gamma radiation) keeps the environment from being burdened with hazardous chemical pesticides. The programme activities of the Agency's Division of Nuclear Safety and Environmental Protection deal with the formulation of the radiation health safety standards and guidelines in the various practices of handling of the nuclear materials for peaceful uses, including the safe disposal of radioactive waste materials from nuclear installations.

Useful current information in these areas of peaceful nuclear applications are disseminated to Member States through scientific meetings and training courses, the provision of technical assistance, fellowships and expert services, and the publication of proceedings, manuals and technical reports. In all these activities, co-operation is maintained with the corresponding programme activities of UNEP, WHO and FAO.

CHEMICAL pollutants from conventional energy and industrial sources released to the environment presumably pose a hazard to man's health and environmental resources. Insufficient knowledge of their detailed mechanisms of interaction with the biological systems seems to provide the greatest drawback in current attempts for realistic assessment of the health risks of chemical pollutants in the short and long terms. Nevertheless, their detrimental health consequences are becoming more and more apparent as a result of recent epidemiological surveys of workers in conventional energy installations and of the chronically exposed general public.

So far nuclear power has succeeded in achieving a remarkable health safety record. In view of its projected expansion, research on biological effects of low-level radiation and radionuclides should continue to re-evaluate the health safety consequences. However, a projection from past experiences together with continued efforts for improvement of health safety aspects seem to justify an expectation that the proposed expansions in the nuclear power programme should not have an unfavourable impact on the environment. The potential hazards and challenges from the associated radiation in man's environment have proved manageable. More attention now needs to be paid urgently to safeguard human health and environment against the chemical pollutants. (*Courtesy*: *IAEA Bulletin, Vol.* 20, *No.* 3).

**Symposium on Plasma Physics and Magneto Hydrodynamics**

The Third National Symposium on Plasma Physics and MHD, organised under the auspices of Department of Atomic Energy, is planned to be held at the Bhabha Atomic Research Centre, Trombay, Bombay-85 during January/February, 1979. The duration of the symposium will be 2—3 days. It is planned to have presentation and poster sessions. The exact dates of the symposium will be announced later.

*Topics for the Symposium*

1. Plasma Flow and Instabilities
2. Electron, Ion and Plasma Sources and Diagnostics
3. Plasma Boundary Interaction and Electrode Phenomena
4. High Temperature and Fusion Plasmas
5. Engineering Aspects of MHD
6. Plasma Technology and Instrumentation
7. Plasma Related Techniques like Electron Beam, Laser and High Voltages.

*The deadline date for extended abstracts is October 31, 1978.*

Those interested in attending the symposium and/or contributing papers may write at the earliest to the symposium convener for further information on the symposium and preparation of abstracts:

V. K. Rohatgi,
Convener, Symposium Committee
Plasma Physics Section
Bhabha Atomic Research Centre
Trombay, Bombay-400 085.

**Workshop on Experimental Data Handling**

*Venue*: Bhabha Atomic Research Centre Bombay-400 085.

*Dates*: Nov. 1—Nov. 15, 1978.

*Number of Participants*: Maximum of 30—10 from India and 20 from other Asian countries.

*Co-Sponsors:* (i) Indian National Science Academy, New Delhi-110 002; (ii) Department of Science and Technology, Govt. of India, New Delhi-110 029; (iii) Bhabha Atomic Research Centre, Department of Atomic Energy, Govt. of India, Bombay-400 085; (iv) Indian Statistical Institute, Documentation Research and Training Centre, Bangalore-560 003; (v) Indian National Scientific Documentation Centre, Council of Scientific and Industrial Research, New Delhi-110 012.

*Topics to be covered*

- Scientific, technical, techno-economic, and social data: their characteristics and differences.
- The problems of accessibility and dissemination of data for science and technology.
- Planning and design of experiments.
- Basic statistical concepts and techniques.
- Data sampling, quantification, collection and analysis.
- Systematic and random errors.
- Errors in data handling.
- Critical evaluation of data.
- Presentation of numerical and non-numerical data.
- Use of computer and telecommunication technology in data services.
- Guidelines for reporting data. Organization for data collection, reporting, dissemination.
- Information/data analysis centres; Structure, function, products.
- Data generation, collection, analysis etc. in different subject-areas.
- Information sources on data centres, etc.
- Data activities in India with special reference to the work of Indian National Committee for CODATA.
- Recent trends and international programmes in data field—CODATA, Unesco, etc.

**The Workshop has the support of the UNESCO and ICSU/CODATA**

### Occurrences of Uranium

Exploration by way of core drilling and/or underground development for uranium has been undertaken in parts of Madhya Pradesh, Meghalaya and Himachal Pradesh, as also in other States. Estimation of the quantities of uranium in these deposits is in progress.

(*Lok Sabha, July 19, 1978*)

### Availability of Atomic Minerals

To increase the availability of atomic minerals, *viz.* uranium, thorium, columbium-tantalum, beryllium etc. in the country, the Government has undertaken a 3–pronged programme (i) to hasten sub-surface examination of the promising uranium occurrences where core drilling and underground development work is currently progressing for assessing their size, grade and economic viability for additional resources, (ii) to further intensify exploration efforts to discover fresh deposits of atomic minerals in various areas still remaining unexplored by extensive ground and air borne surveys using latest geological, geophysical and geochemical techniques, and (iii) to strengthen instrumentation and analytical facilities to back-up the exploration efforts.

Areas where sub-surface exploration by core drilling has already been started are Bodal-Bhandaritola,, Dist. Rajnandgaon, Dumhat-Jajawal-Garia, Dist. Sarguja, Madhya Pradesh, Astotha, Loharain, Khya, Dist. Hamirpur, Himachal Pradesh, Ingedinala, Dist. Tehri, Uttar Pradesh and Bagjata and Gohala, Dist. Singhbhum, Bihar and at Anek, Dist. Garo Hills, and Gomaghat, Khasi Hills Dist. Meghalaya. Similar investigations are likely to start during the next five years at Sibal, Dist. Hamirpur, Himachal Pradesh, foot hills of Darjeeling Himalayas and Walkunje, South Kanara Dist. Karnataka, and other localities depending upon the results of the surveys.

Exploration so far carried out by the Atomic Minerals Division has placed the country in a reasonably comfortable position in regard to nuclear raw materials, that is, thorium, zirconium, beryllium, columbium, tantalum etc. As for uranium, one mine at Jaduguda is under operation. Another deposit at Bodal is fairly in advanced stage of exploration, while work has recently been started at Jajawal and Astotha-Khya areas where core drilling, coupled with underground work, is in progress.

(*Rajya Sabha, July 27, 1978*)

### Self-Sufficiency

Production units have not yet been planned for the newly discovered uranium deposits in parts of Rajnandgaon and Sarguja districts of Madhya Pradesh and in the Hamirpur district of Himachal Pradesh, which are still under evaluation. However, production plans are under technical scrutiny in respect of Bodal deposit in Madhya Pradesh.

Nuclear energy is only one of three types of bulk power generating sources. Power generation cannot therefore depend solely on the capabilities of nuclear energy. Experience has shown that Hydro power is best for peak loads and nuclear power is best for base loads. The policy of Government is to exploit all the three types to meet the energy demands of the country.

(*Rajya Sabha, July 27, 1978*)

### Heavy Water Plants

Four heavy water plants are being up in the country—one each at Tuticorin, Talcher, Kota and Baroda. In Tuticorin production of heavy water started on July 17, 1978. Commissioning of the Heavy Water Plant at Talcher and Kota is expected to start in February and May, 1979 respectively. The Heavy Water Plant at Baroda suffered a set-back due to a mishap to the machinery and is likely to be recommissioned by the third quarter of 1979.

All efforts are being made to commission these plants according to schedule. It is expected that heavy water from domestic production will be available for Madras and Narora Atomic Power Stations. It is also proposed to set up a few more Heavy Water Plants in the VIth and VIIth Five-Year Plan periods to meet the future requirements of heavy water for the nuclear power programme.

(*Rajya Sabha, July 27, 1978*)

### Supply of Enriched Uranium

U.S. authorities have given no indication that they will not honour their obligations under the existing Co-operation Agreement for continued supplies of enriched uranium for the Tarapur Atomic Power Station. In fact in view of the provisions of the Non-Proliferation Act they are wanting to negotiate consequential changes.

(*Lok Sabha, August 9, 1978*)

### French Co-operation

Letters were exchanged in July 1978 between the Commissariat A l'Energie Atomique, France, and the Atomic Energy Commission of India constituting an agreement for co-operation in the field of peaceful uses of atomic energy between the two countries. This agreement is in force and co-operation has been proceeding in a satisfactory manner.

(*Rajya Sabha, August 10, 1978*)

**Nuclear India is published around the 20th of each month. To ensure prompt attention, all communications should be addressed to the Editor, NUCLEAR INDIA, Department of Atomic Energy, Chhatrapati Shivaji Maharaj Marg, Bombay 400 039.**

Edited and published by Jagannath Sharma, Publications Officer, Dept. of Atomic Energy, Government of India,
Chhatrapati Shivaji Maharaj Marg, Bombay 400 039, and printed by him at G. Claridge & Co. Ltd., Bombay 400 001.

**Registered No. R. N. 9002/62**